L-2861

TestMate® Contamination Monitor
Operating and Maintenance Instructions

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Contents

Contents **2**

Safety information **6**

Hazard symbols 6
Signal words and their meaning in the safety information and instructions 6
Structure of the safety information and instructions 7
Observe regulatory information 7
Proper/Designated Use 7
Improper Use or Use Deviating from Intended Use 8
Qualifications of personnel / target group 9

Storing the TCM **10**

Storage conditions 10

Decoding the model code label **10**

Checking the scope of delivery **10**

TCM Features **11**

TCM Restrictions on use **12**

TCM1x1x dimensions (without display) **12**

TCM1x2x dimensions (with display) **13**

Hydraulic connection types **13**

Pipe or hose connection (type TCM) 13
Flange connection type (type TCM) 14

Fastening / mounting the TCM **14**

Display rotatable/Adjustable As Needed **16**

TCM hydraulic installation **16**

Selecting the measurement point 17
Flow rate, differential pressure Δp and viscosity ν characteristiTCM 18
Hydraulic connection of the TCM 19

Electrical connection of the TCM **20**

Pin assignment 20
Connection cable - assignment / color coding 21
Connecting cable ends - Examples 22

Setting the measuring mode **22**

Mode M1: Continuous measurement 23
Mode M2: Continuous measurement and switching 23
Mode M3: Filter to cleanliness class and stop 23
Mode M4: Filter to continuously monitor cleanliness class 23
Mode "SINGLE" measurement 24

Operating the TCM1x2x using the keypad **24**

Function of the Keys 25
Measured variables on the display 25
ISO (Cleanliness class) ..... **Error! Bookmark not defined.**

SAE (Cleanliness class) ..... **Error! Bookmark not defined.**
NAS (Cleanliness Class - only TCM 13xx) ..... **Error! Bookmark not defined.**
Service variables on the display 26
Flow (flow rate) 26
Out (Analog output) ..... **Error! Bookmark not defined.**
Drive (performance of the LED) ..... **Error! Bookmark not defined.**
Temp (Temperature) ..... **Error! Bookmark not defined.**
Activate / deactivate keypad lock. 27
Display FREEZE 28
Activate display FREEZE 28
Deactivate display FREEZE 29
Menus and modes 30
PowerUp Menu 30
Measuring Menu (TCM12xx) 32
DSPLAY - Display after sensor is switched on 33
SWT.OUT – Schaltausgang konfigurieren 33
ANA.OUT - Set output signal at analog output 35
Measuring menu (TCM13xx) 36
DSPLAY - Display after sensor is switched on 36
SWT.OUT – Configure switching output 37
ANA.OUT - Set output signal at the analog output 39

Overview of menu structure 39
Menu TCM 12xx (ISO 4406:1999 and SAE) 39
Menu TCM 13xx (ISO 4406:1987 and NAS / ISO4406:1999 and SAE 4059 D) 41

Using switching output 42
Mode M1: Continuous measurement 42
Mode M2: Continuous measurement and switching 42
Mode M3: Filter to cleanliness class and stop 42
Mode M4: Filter to continuously monitor cleanliness class 42
Mode "SINGLE" measurement 43

Setting limit values 43

Reading the analog output 45
SAE classes acc. to AS 4059 45
SAE A-D 46
SAE Class A / B / C / D 46
SAE A / SAE B / SAE C / SAE D 47
SAE + T 48
HDA.SAE – Analog signal SAE to the HDA 5500 49
HDA.SAE Signal 1/2/3/4 50
HDA.SAE signal 5 (status) 50
ISO code acc. to ISO 4406:1999 52
ISO 4 / ISO 6 / ISO 14 52
ISO code, 3-digit 53
ISO + T 54
HDA.ISO – Analog signal ISO to HDA 5500 55
HDA.ISO Signal 1/2/3/4 56
HDA.ISO signal 5 (status) 56

ISO code signal acc. to ISO 4406:1987 (TCM 13xx only) ... 58
ISO 2 / ISO 5 / ISO 15 ... 58
ISO code, 3-digit ... 59
ISO + T ... 60
HDA.ISO – Analog signal ISO to HDA 5500 ... 61
HDA.ISO Signal 1/2/3/4 ... 62
HDA.ISO signal 5 (status) ... 63
NAS 1638 - National Aerospace Standard (Only TCM 13xx) ... 64
NAS maximum ... 64
NAS classes (2 / 5 / 15 / 25) ... 65
NAS 2 / NAS 5 / NAS 15 / NAS 25 ... 66
NAS + T ... 66
HDA.NAS – Analog Signal NAS to HDA 5500 ... 67
HDA.NAS Signal 1/2/3/4 ... 68
HDA.NAS signal 5 (status) ... 69
Fluid temperature TEMP ... 70

Status Messages ... 70
Status LED / Display ... 70
error ... 72
Exceptions Errors ... 73
Analog Output Error Signals ... 75
Analog signal for HDA 5500 ... 76
HDA Status Signal 5 Table ... 76

Connecting TCMI-D-5 (Condition Sensor Interface) ... 78
TCMI-D-5 Connection overview ... 78

Connecting the TCM to an RS485 bus ... 78

Communicating with the TCM via the RS485 bus ... 79

Taking the TCM out of operation ... 80

Disposing of TCM ... 80

Spare Parts and Accessories ... 80

Cleanliness classes - brief overview ... 81
Cleanliness class - ISO 4406:1999 ... 81
Table - ISO 4406 ... 81
Overview of modifications - ISO4406:1987 <-> ISO4406:1999 ... 82
Cleanliness class - SAE AS 4059 ... 82
Table - SAE AS 4059 ... 83
Definition acc. to SAE ... 83
Particle count (absolute) larger than a defined particle size ... 83
Specifying a cleanliness code for each particle size ... 83
Specifying highest measured cleanliness class ... 84
Cleanliness Class - NAS 1638 ... 84

Checking/resetting default settings ... 85
PowerUp menu ... 85
Measuring menu ... 85

Specifications ... 85

Recalibration **87**
Customer Service **87**
Glossary **87**

Safety information

The device was built according to the statutory provisions valid at the time of delivery and satisfies current safety requirements.

Any residual hazards are indicated by safety information and instructions and are described in the operating instructions.

Observe all safety and warning instructions attached to the unit. They must always be complete and legible.

Do not operate the device unless all the safety devices are present.

Secure the hazardous areas which may arise between the unit and other equipment.

Maintain the unit inspection intervals prescribed by law.

Document the results in an inspection certificate and keep it until the next inspection.

Hazard symbols

These symbols are listed for all safety information and instructions in these operating instructions which indicate particular hazards to persons, property or the environment.

Observe these instructions and act with particular caution in such cases.

Pass all safety information and instructions on to other users.

General hazard

Danger due to electrical voltage / current

Danger due to operating pressure

Signal words and their meaning in the safety information and instructions

DANGER

DANGER indicates a hazard with a high risk and which will lead to death or serious injury if

not avoided.

WARNING

WARNING indicates a hazard with a medium risk and which can lead to death or serious injury if not avoided.

CAUTION

CAUTION indicates a danger with a low risk and which can lead to minor injury if not avoided.

NOTICE

NOTICE indicates a hazard which will lead to damage to property if not avoided.

Structure of the safety information and instructions

All warning instructions in this manual are highlighted with pictograms and signal words. The pictogram and the signal word indicate the severity of the danger.

Warning instructions listed before an activity are laid out as follows:

HAZARD SYMBOL	**SIGNAL WORD**
	Type and source of danger Consequence of the danger
	► Measures to avert danger

Observe regulatory information

Observe the following regulatory information and guidelines:

- Legal and local regulations for accident prevention
- Legal and local regulations for environmental protection
- Country-specific regulations, organization-specific regulations

Proper/Designated Use

Only use the sensor for the application described in the following.

The TestMate® Contamination Sensor module serves to continuously monitor particulate contamination in hydraulic and lubrication systems.

Proper or designated use of the product extends to the following:

- observing all instructions contained in the instruction manual.

- performing inspection and maintenance work.

Depending on the version (see model code), you may only use the TCM device in connection with the following media:

NOTICE

Impermissible operating media

The TestMate® Contamination Sensor will be destroyed.

► Only operate the TestMate® Contamination Sensor with the permitted operating fluids:
- the **TCM 1xx0** is suitable for operation with mineral oils or mineral-oil-based raffinates.
- **TCM 1xx1** is suitable for phosphate esters.

► Note the maximum operating pressure of 350 bar / 5075 psi.

Improper Use or Use Deviating from Intended Use

DANGER

Hazard due to use of the unit other than that intended

Bodily injury and damage to property will result when operated improperly.

► Never operate the sensor in potentially explosive atmospheres.

► The sensor is only to be used with the permitted media.

Any use extending beyond or deviating therefrom shall not be considered intended use. SCHROEDER Filter Systems will assume no liability for any damage resulting from such use. The user alone, shall assume any and all associated risk

Improper use may result in hazards and/or will damage the sensor. Examples of improper use:

- Operation in potentially explosive atmospheres.
- Operation with a non-approved medium.
- Operation under non-approved operational conditions.
- Operation when the safety devices are defective.

- Modifications to the sensor made by the user or purchaser.
- Inadequate monitoring of parts that are subject to wear and tear
- Improperly performed repair work.

Qualifications of personnel / target group

Persons who work on the sensor must be aware of the associated hazards when using it.

Auxiliary and specialist personnel must have read and understood the operating instructions, in particular the safety information and instructions, and applicable regulations before beginning work.

The operating instructions and applicable regulations are to kept so they are accessible for operating and specialist personnel.

These operating instructions is intended for:

Auxiliary personnel: such persons have been instructed about the sensor and are aware of potential hazards due to improper use.

Specialist personnel: such persons with corresponding specialist training and several years work experience. They are able to assess and perform the work assigned to them, they are also able to recognize potential hazards.

Activity	Person	Knowledge
Transport / storage	Forwarding agent Specialist personnel	• Proof of knowledge of cargo securing instructions • Safe handling/operation of hoisting and lifting equipment
Hydraulic / electrical installation, first commissioning, maintenance, troubleshooting, repair, decommissioning, disassembly	Specialist personnel	• Safe handling/use of tools • Fitting and connection of hydraulic lines and connections • Fitting and connection of electrical lines, electrical machinery, sockets, etc. • Checking the phase sequence • Product-specific knowledge
Operation Operations control	Specialist personnel	• Product-specific knowledge • Knowledge about how to handle operating media.
Disposal	Specialist personnel	• Proper and environmentally-friendly disposal of materials and substances • Decontamination of contaminants • Knowledge about reuse

Storing the TCM

Store the TCM in a clean, dry place, in the original packing, if possible. Do not remove the packing until you are ready to install the unit.

Rinse the TCM completely with Cleanoil before putting it into storage.

The solvents and flushing oils used must be handled and disposed of correctly.

Storage conditions

Storage temperature:	-40 °C … 80 °C / -40 °F … + 176 °F
Relative humidity:	maximum 95%, non-condensing

Decoding the model code label

For product identification details see the Model code label. This is located on the back of the unit and contains the exact product description and the serial number.

Row	Description
Model	Model code; for details, see page **Error! Bookmark not defined.**
P/N	Part no.
S/N	Serial no.
Date	Year/week of production and hardware index
Max. INLET press.:	Maximum operating pressure

Checking the scope of delivery

The TestMate® Contamination Sensor TCM comes packed and factory-assembled, ready for operation. Before starting up the TCM, check that the content of the package is complete.

The following items are supplied:

Qty.	Description
1	TestMate® Contamination Sensor , TCM series (Model in acc. with the order - see model code)
2	O-rings (4.8 x 1.78 mm, 80 Shore, FKM) (Only with connection type "Flange connection" =

	model code: TCM1xxx-x-x-x-x-1/-xxx)
1	FMM-P upgrade kit with installation instructions (Only with connection type "Flange connection" = model code: TCM1xxx-x-x-x-x-1/-xxx)
1	CD with TCM operation and maintenance instructions (this document in various languages)
1	CD with FluMoS software (fluid monitoring software)
1	Quick start manual
1	Calibration certificate

TCM 1x2x TCM 1x1x

TCM Features

The TCM Series Contamination Sensor is a stationary measurement unit for the continuous monitoring of particulate contamination in hydraulic and lubrication systems.

The TCM is designed to be used in low- or high-pressure hydraulic and lubrication circuits and test benches where a small amount of oil (between 30 ml/min and 500 ml/min) is diverted for measurement purposes.

The TestMate® Contamination Sensor is approved for a maximum operating pressure (see specification on type label) and viscosity of up to 1000 mm²/s.

Particulate contamination is detected with an optical measurement cell

The sensor is available with the following options:

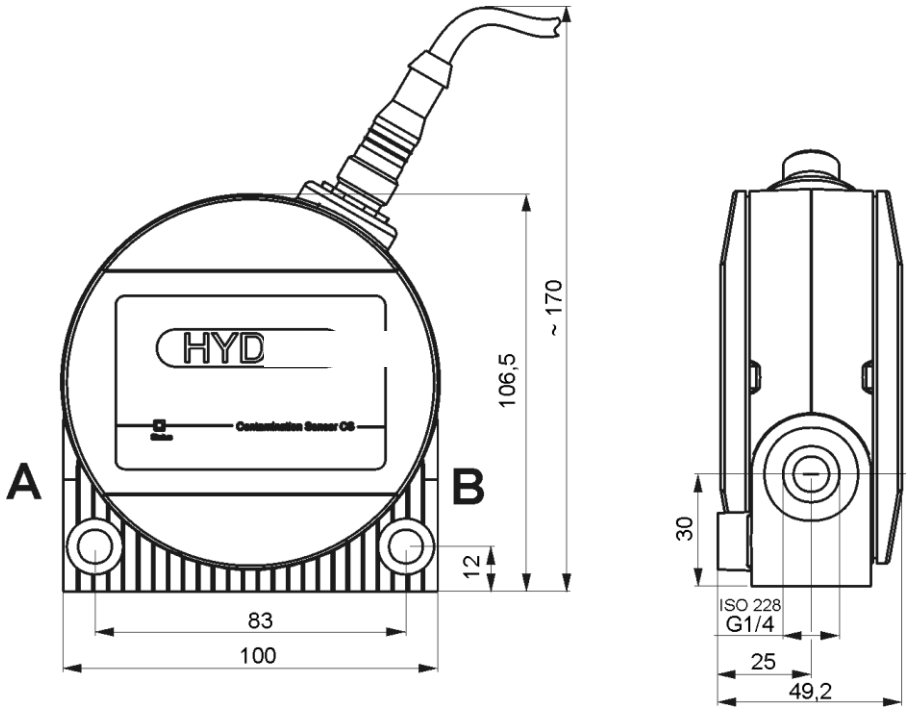
- with or without 6-digit display and keypad (can be rotated by 270°)
- with a 4 … 20 mA or 2 … 10 V analog output
- Results are output as a cleanliness code according to:
  ISO 4406:1999 and SAE AS 4059(D) or
  ISO 4406:1987 and NAS or ISO4406:1999 and SAE AS 4059(D)

- pipe / hose installation or flange installation

All models feature an analog electric output and an RS485 interface for outputting the measured cleanliness class. In addition, all TCM's have a switching output.

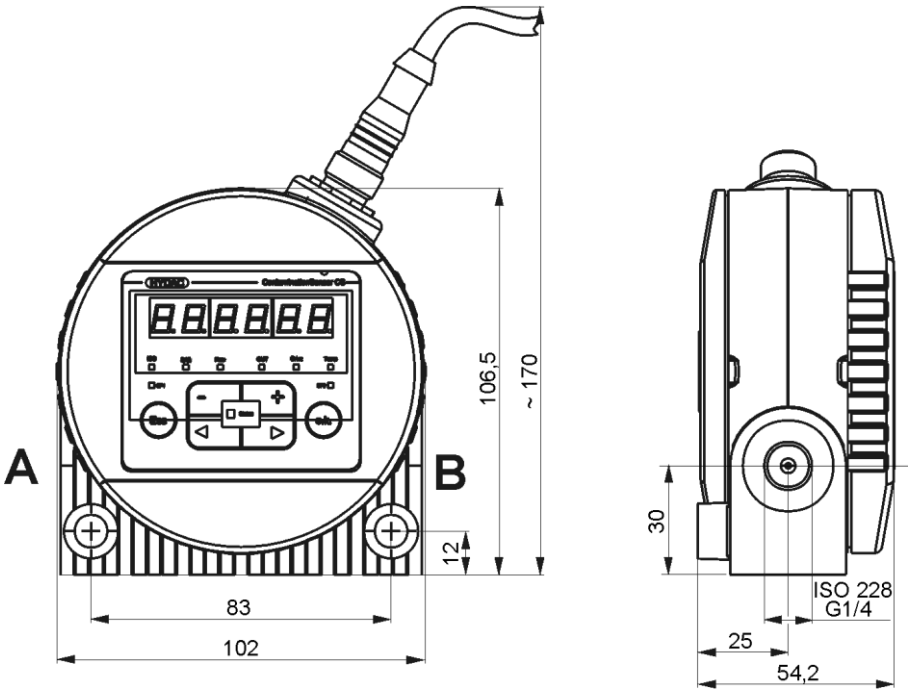
TCM Restrictions on use

TCM1x1x dimensions (without display)



All dimensions in mm.

TCM1x2x dimensions (with display)



All dimensions in mm.

Hydraulic connection types

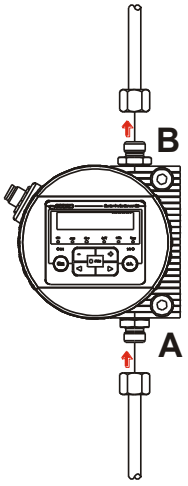
If possible, install the TCM in such a way that the flow runs from bottom to top to avoid air collecting in the sensor. If it is not possible to install it like that, take other measures to ensure that air cannot collect in the sensor.

Use port A / C as the INLET and B / D as the OUTLET.

Pipe or hose connection (type TCM)

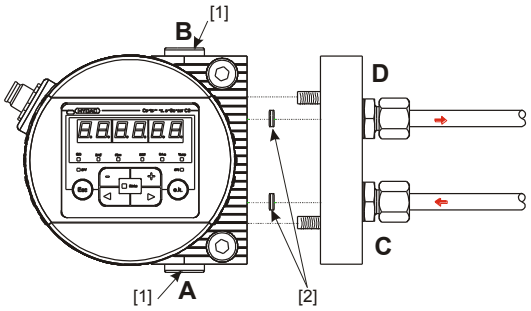
Hydraulic connection is done via ports A and B. Connection thread G1/4 according to ISO 228.

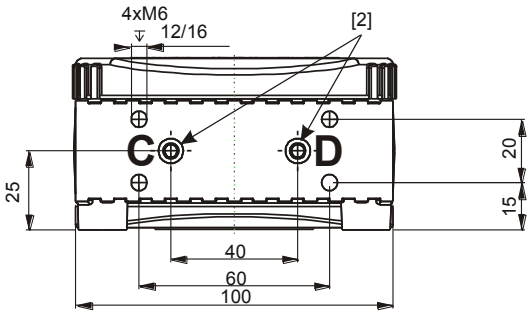
Make sure that the flow runs through the sensor from bottom (A) to top (B).



Flange connection type (Type TCM)

Hydraulic connection is done via ports C and D. Two O-rings are used to form a seal between the TCM and a flange, connecting plate or manifold mount. Four M6 threads are prepared for fixing the TCM. Ports A and B are sealed off with screw plugs [1]. Sealing with the manifold block or mounting plate is done via two O-rings [2] (4.48 x 1.78 FPM, see Chapter "Spare Parts + Accessories").





View from below.
All dimensions in mm.

Fastening / mounting the TCM

Install the TCM in such a way that the flow runs from bottom to top.

Use the one (lower) port as the INLET and the other (upper) port as the OUTLET.

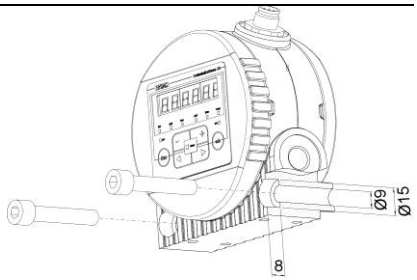
When selecting the installation site, take ambient factors like the temperature, dust, water, etc. into account.

The TCM is designed for IP67 according to DIN 40050 / EN 60529 / IEC 529 / VDE 0470.

Mount the sensor as shown in the following examples:

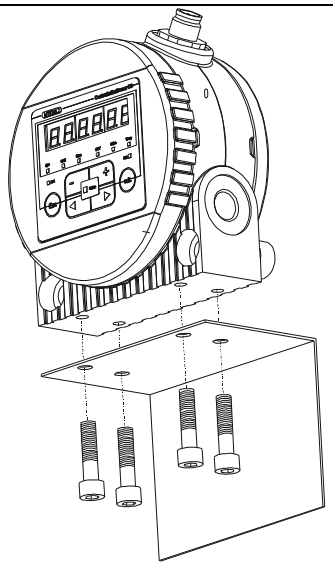
1. Wall mounting:

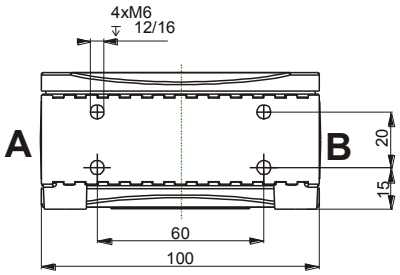
   Mount to a wall using two cylindrical screws having an M8 hexagonal socket according to ISO 4762 and having a length of at least 40 mm.



2. Console mounting:

   Mount to a console using 4 cylindrical screws having an M6 hexagonal socket according to ISO 4762.



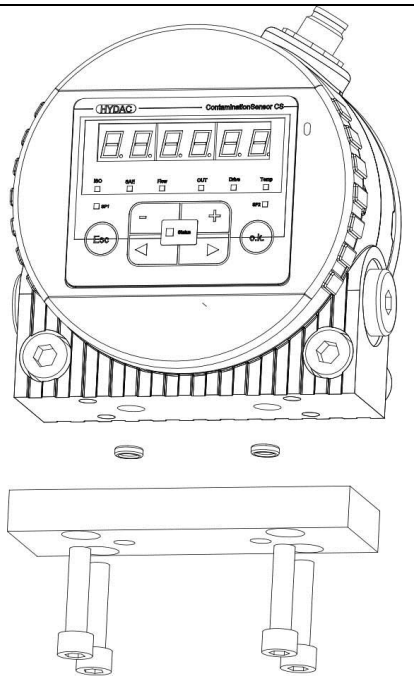


Bottom view

All dimensions in mm.

3. Installing on a mounting plate:

   Mount to a mounting plate or control block using 4 cylindrical screws having an M6 hexagonal socket according to ISO 4762.

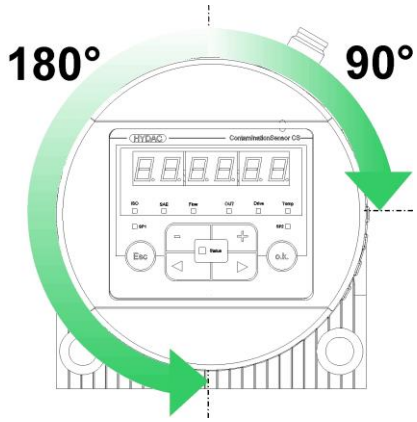


Display rotatable/Adjustable As Needed

The display can be continuously rotated by a total of 270°; 180° counterclockwise and 90° clockwise.

Rotate the display by hand in the corresponding direction.

No tools are required for rotating the display.



TCM hydraulic installation

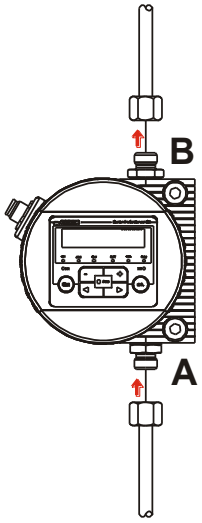
If possible, install the TCM so that fluid flows from bottom to top to avoid air collecting in the sensor. If it is not possible to install it like that, take other measures to ensure that air cannot collect in the sensor.

Use port A / C as the INLET and B / D as the OUTLET.

Depending on your order, the TCM features the following hydraulic connection types:

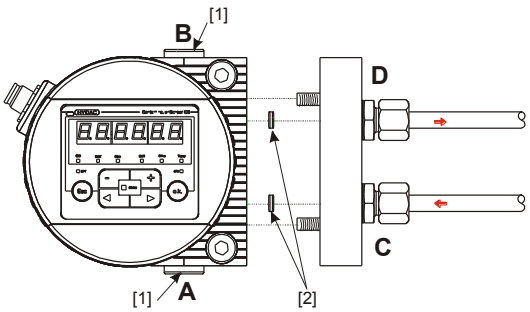
Pipe/hose connection

The TCM is connected to the hydraulic system via ports A and B using a pipe or hose.



Flange connection

The TCM is screwed to a flange, connecting plate, manifold mount or control block, with flow through the unit via ports C and D on the bottom. Ports A and B exist but are sealed with a screw plug.



Determine the operating pressure of the hydraulic system and see whether it is within the permissible flow range for the TCM inlet.

NOTICE

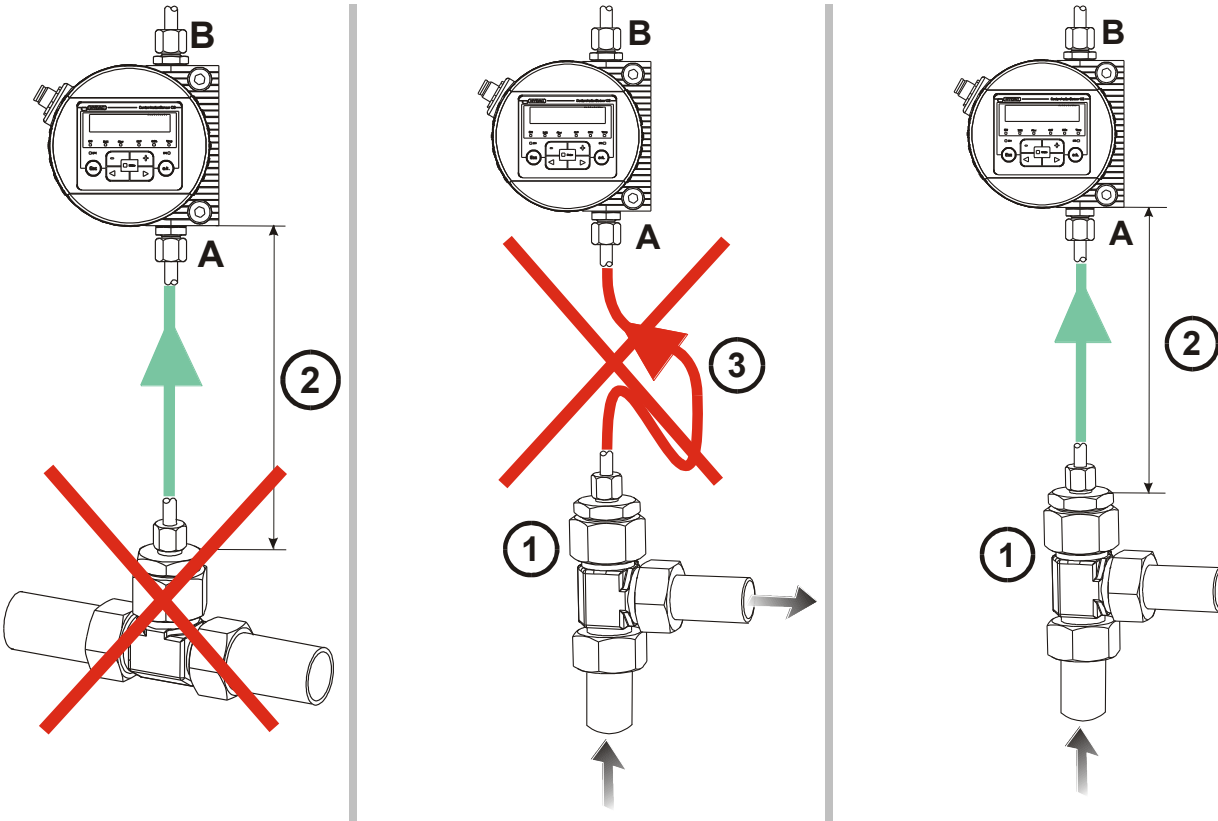
Excessive operating pressure

The TestMate® Contamination Sensor will be destroyed.

► Note the maximum operating pressure of 350 bar / 5075 psi.

Selecting the measurement point

In order to obtain cleanliness values that are continuous and coherent in real time, select a suitable measuring point according to the following guidelines:



1 Select the measurement point so that the sample measured comes from a turbulent location, wit good flow. For example: on a pipe elbow, etc.

2 Install the sensor near the measurement point to achieve as timely results as possible.

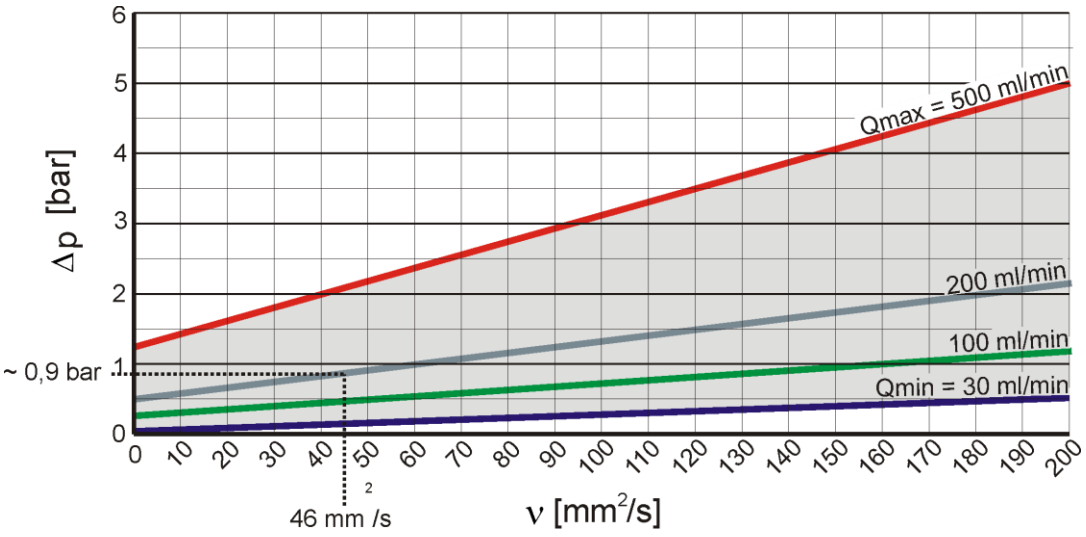
3 During installation, avoid creating a "siphon" trap for particle deposits in the line (sedimentation).

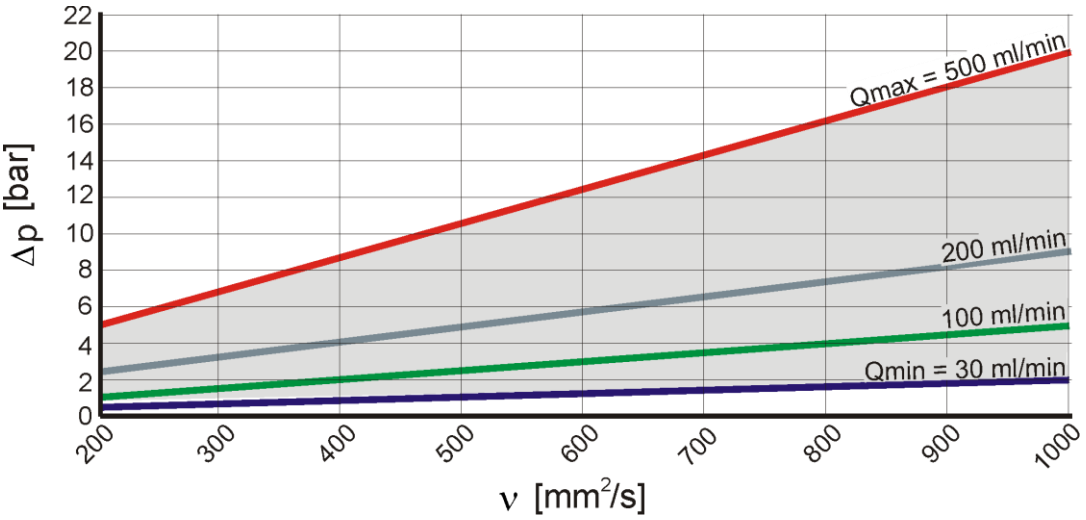
Flow rate, differential pressure Δp and viscosity ν characteristiTCM

Differential pressure Δp and viscosity ν characteristiTCM. All the values indicated in the figures below apply regardless whether the direction of flow is A->B or B->A.

Note that the permissible measured volumetric flow is 30 … 500 ml/min.

If you are unable to achieve the required flow values, we offer an extensive line of accessories with various conditioning modules.





For example:

You are using a fluid with a viscosity ν of 46 mm²/s at a pressure difference Δp of ~0.9 bar, so that you achieve a flow rate of approx. 200 ml/min.

The flow rate depends on the viscosity of the medium and the differential pressure Δp via the sensor.

Hydraulic connection of the TCM

NOTICE

Excessive operating pressure

The TestMate® Contamination Sensor will be destroyed.

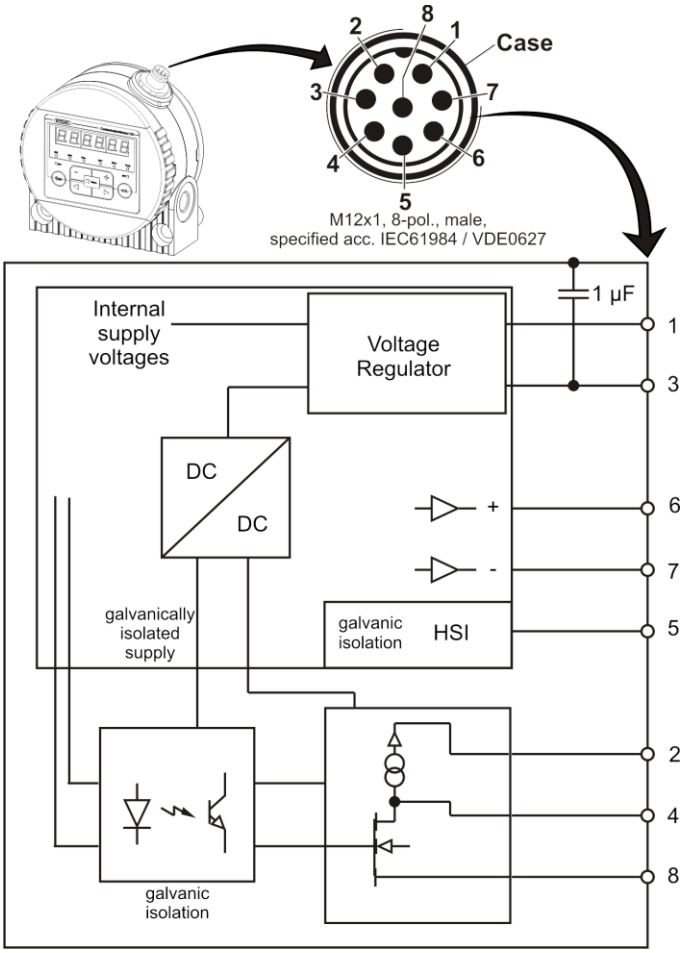
► Note the maximum operating pressure of 350 bar / 5075 psi.

Observe the following sequence when connecting the sensor to the hydraulic system:

1.	Connect the return line to the outlet of the TCM. G1/4 ISO 228 threaded connection, recommended diameter of line ≥ 4 mm.
2.	Then connect the other end of the return line to the system tank, for example.
3.	Check the pressure at the measurement location. Note the maximum operating pressure.
4.	Connect the measurement line to the inlet of the TCM. G1/4 ISO 228 threaded connection. We recommend an internal Ø ≤ 4mm for the line in order to prevent particle deposits (sedimentation). If particles ≥ 400 µm are anticipated in the hydraulic system, install a strainer upstream from the TestMate® Contamination Sensor . (e.g. CM-S).
5.	Connect the other end of the measurement line to the measurement point on the hydraulic system. Oil begins to flow as soon as the TestMate® Contamination Sensor is connected with the pressure line.
6.	The hydraulic connection is complete.

Electrical connection of the TCM

Pin assignment



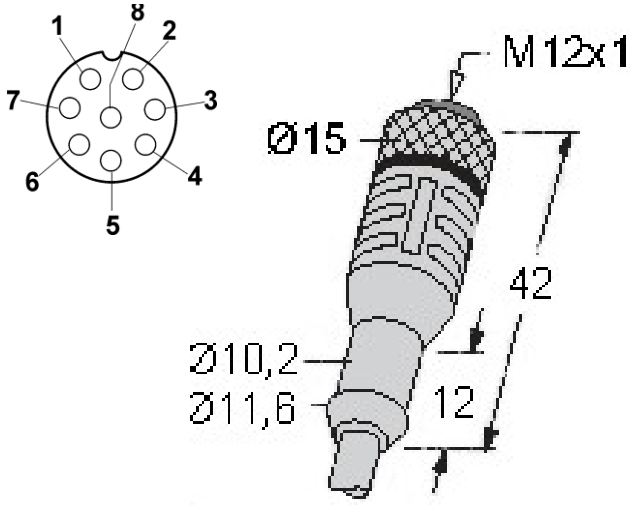
Pin	Assignment
1	Supply voltage 9 ... 36 V DC
2	Analog output + (active)
3	GND supply voltage
4	GND ANALOG / SWITCH OUTPUTS
5	HSI (**SCHROEDER S**ensor **I**nterface)
6	RS485 +
7	RS485 -
8	Switching output (passive, n.c.)

The analog output is an active source of 4 ... 20 mA or 2 ... 10 V DC.
The switching output is a passive n-switching power MOSFET and is normally open. There is contact between the plug housing and the housing.

Connection cable - assignment / color coding

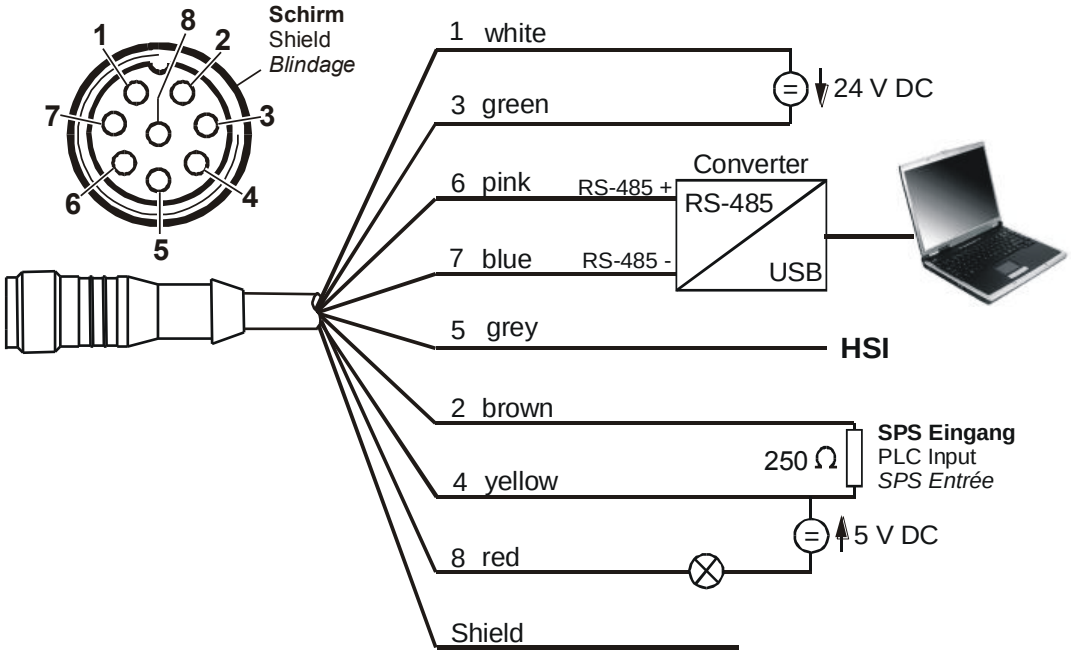
Our accessories list on page 80 includes the required connection cables of various lengths with one connection plug (8-pole, M12x1, according to DIN VDE 0627) and an open end.

SCHROEDER accessory cable color coding is listed in the table below.

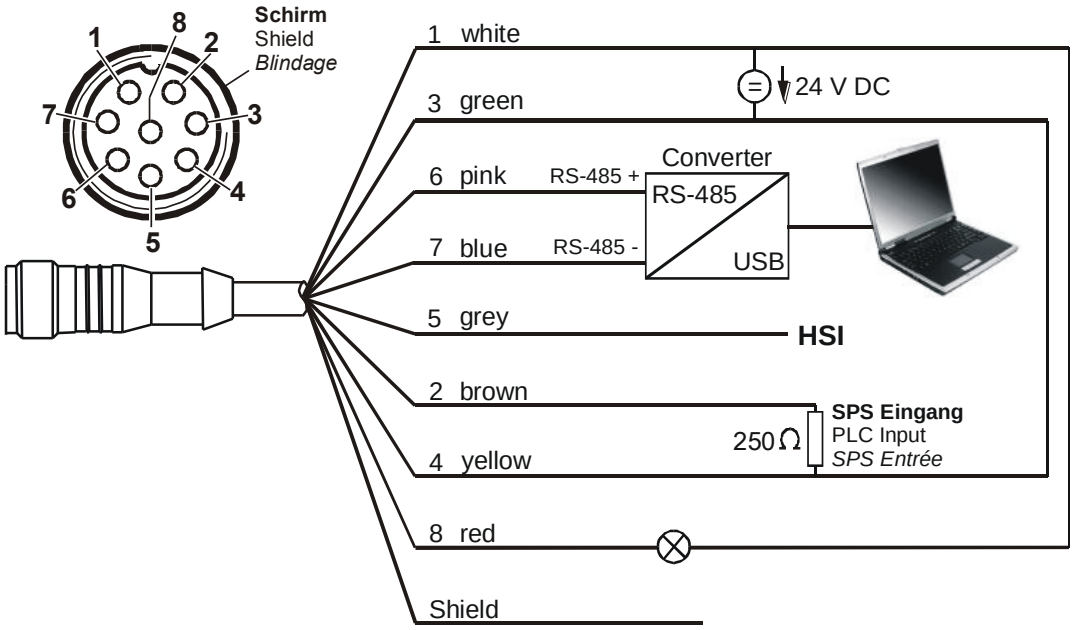


Pin	Colour	Connection to
1	White	Supply voltage 9 ... 36 V DC
2	brown	Analog output + (active)
3	Green	GND supply voltage
4	yellow	GND ANALOG / SWITCH OUTPUTS
5	grey	HSI (**SCHROEDER S**ensor **I**nterface)
6	Pink	RS485 +
7	blue	RS485 -
8	Red	Switching output (passive, n.c.)
Housing	-	screen

Connecting cable ends - Examples



Circuit diagram: with two separate power supplies. (e.g. 24 V DC and 5 V DC)



Circuit diagram: with one power supply. (e.g. 24 V DC).

To prevent a ground loop, connect the shield of the connector cable if and only if the TCM is not grounded or not sufficiently connected to the PE conductor.

Setting the measuring mode

Once the sensor is switched on or supplied with power, it automatically runs in the measuring mode that has been set.

Mode M1: Continuous measurement

Application:	Stand-alone sensor
Data output:	Display & RS485 & analog output
Purpose:	Measurement only
Function:	Continuous measurement of cleanliness class Switching function only for "Device ready".

Mode M2: Continuous measurement and switching

Application:	Stand-alone sensor with alarm standby display
Data output:	Display & RS485 & analog output & switching output
Purpose:	Continuous measurement and controlling of signal lamps etc.
Function:	Continuous measurement of solid contamination, continuous monitoring of programmable limit values; switching output is activated to switch on the monitor display or an alarm on site

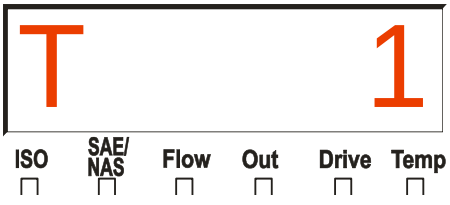
Mode M3: Filter to cleanliness class and stop

Application:	Controlling a filter unit
Data output:	Display & RS485 & analog output & switching output
Purpose:	For cleaning up a hydraulic reservoir
Function:	Control of a filter unit, continuous measurement of solid contamination. If pre-programmed cleanliness level is achieved 5 times in sequence, the pump is stopped. Load the switching output with a maximum of 2 A and 30 V DC.

Mode M4: Filter to continuously monitor cleanliness class

Application:	Control of stationary offline filtration unit
Data output:	Display & RS485 & analog output & switching output
Purpose:	Establish continuous monitoring of cleanliness class between min./max. limit values.
Function:	Control of a filter unit, continuous measurement of solid contamination. If min./max. limit values are pre-programmed, the TCM switches the filtration unit on/off to maintain the cleanliness within the limit value range.

Once the target cleanliness has been reached (5x undershooting of the TARGET), the set test cycle time in minutes appears on the display. The test cycle time expires.



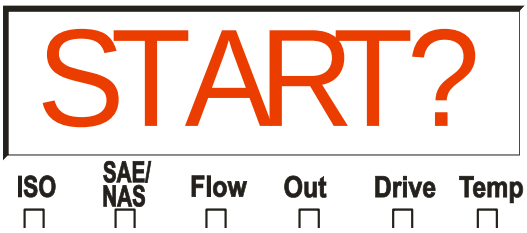
After the test cycle time has elapsed, the switching output is closed and a measurement is started. If the result is still below the TARGET cleanliness, the test cycle time (CYCLE) begins again.

Mode "SINGLE" measurement

Application:	Stand-alone sensor
Data output:	Display & RS485 & analog output
Purpose:	Perform a single measurement and "stop" the result.
Function:	Single measurement of solid contamination without switching functions

When Single mode is selected in the PowerUp menu, the display jumps directly to the following message after switching to the Measuring menu or after switching the TCM on:

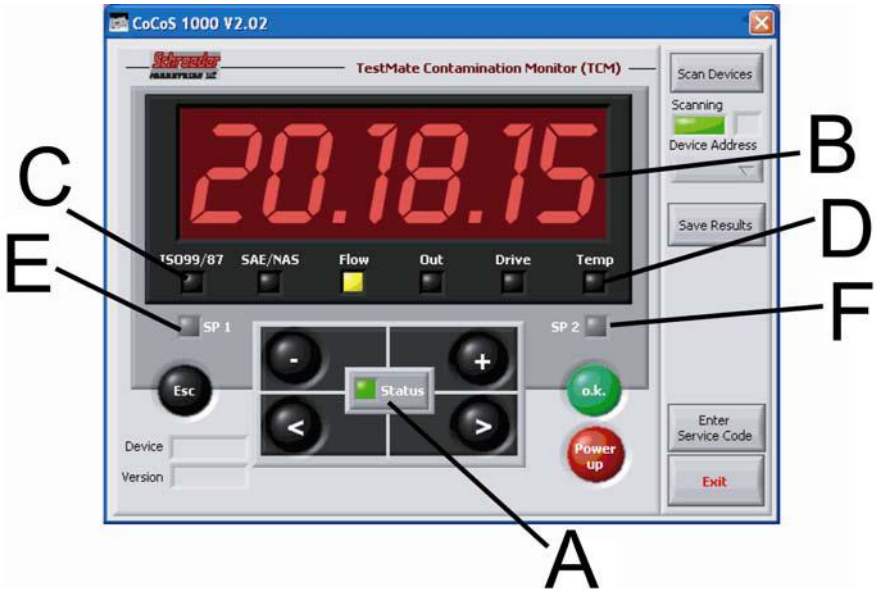
The TCM begins with individual measurement after the message has been confirmed by pressing o.k. .



Operating the TCM1x2x using the keypad

If the sensor is switched on or supplied with power, the display shows SCHROEDER TCM in moving letters, then the firmware version is displayed for 2 seconds.

This is followed by a countdown: **WAIT99** ... **WAIT0**.
The duration of the countdown corresponds to the set measurement time MTIME. This means that the countdown runs from 99 ... 0 within the set measurement time (factory setting = 60 sec).



Item	LED	Description	For details, see page
A	Status	Status display	70
B	Display	6-figure display with 17 segments each	70
C	Measured variable	Display of respective measured variable, e.g: **ISO / SAE / NAS**	25
D	Additional variable	Display of respective service variable, e.g.: **Flow / Out / Drive / Temp**	26
E	Switch point 1	Indicates the status of the switching output. When the LED is lit, the switching output is activated, i.e. the switch is closed.	42
F	Switch point 2	Reserved	

Function of the Keys

The following keys are available to you for operating and setting the TCM1x2x.

Key	Function
o.k.	You jump one menu level down. You confirm a changed value at the lowest menu level. You confirm at the top menu level to save or reject a change in value.
Esc	You jump up one menu level. In order to leave the menu without changing the values, press the ESC key until SAVE appears in the display. With the ◀ ▶ keys switch to CANCEL and confirm with the o.k. key or wait 30 seconds without pressing a key. You exit the menu without changing the values.
− +	You change values / settings on the lowest menu level.
◀ ▶	You scroll through the display ISO / SAE/NAS / Flow / Out / Drive / Temp. You move through the menu. You select numbers.

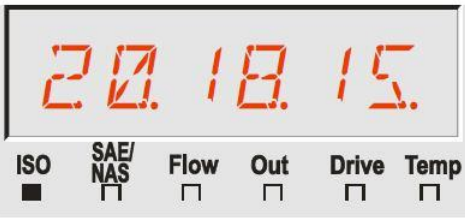
Once the lowest menu level has been reached, the values in the display will start to flash.

Measured variables on the display

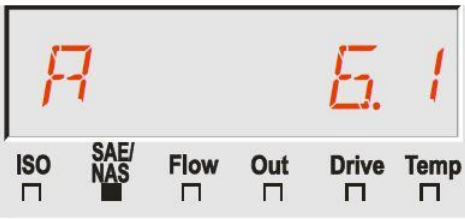
The measured variables give you information on the oil cleanliness in the system.

You will gain a measured value with an accuracy of ± 1/2 ISO code within the calibrated range.

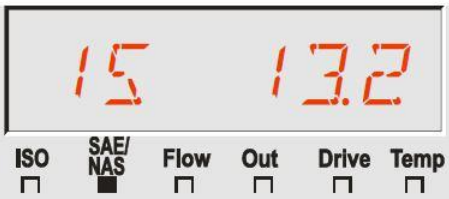
ISO (Cleanliness class)

Display	Description
	Measured value ISO code

SAE (Cleanliness class)

Display	Description
	SAE class measurement category

NAS (Cleanliness Class - only CS 13xx)

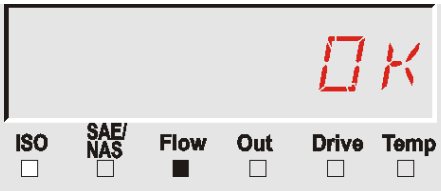
Display	Description
	NAS class measurement category

Service variables on the display

The service variables inform you about the current status in the TestMate® Contamination Sensor .

The service variables are not calibrated. They represent an approximate value for installing the sensor in the hydraulic system.

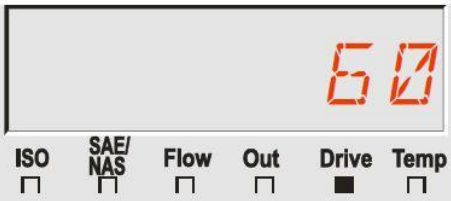
Flow (flow rate)

Display	Description
	Flow rate in permissible range

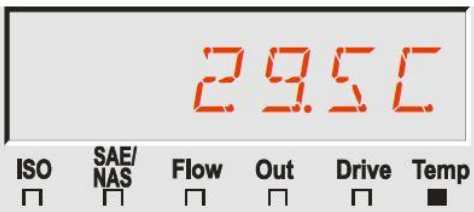
Out (Analog output)

Display	Description
	Current or voltage output at the analog output. (example: 13.8 mA)

Drive (performance of the LED)

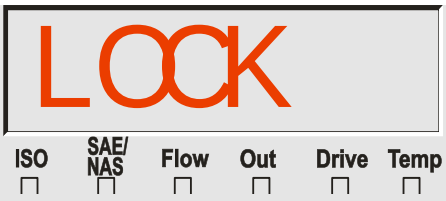
Display	Description
	Performance (1-100%) of the LED in the sensor.(example: 60%)

Temp (Temperature)

Display	Description
	Fluid temperature in the sensor. (example: 29.5 °C or 84.2 °F)

Activate / deactivate keypad lock.

Activate or deactivate the keypad lock by pressing both keys simultaneously to prevent further input.

Keys	The following appears in the display (1 sec)	Description
		Activating key lock

		Deactivating key lock

The display switches to the preset display after 1 second.

When the supply voltage to the TCM is disconnected, the activated keypad lock "LOCK" is unlocked and reset to "UNLOCK".

Display FREEZE

This function makes it possible for you to call up the last 20 displayed values on the display.

The active display is then frozen in the set MTIME cycle.

The display FREEZE function is based on a volatile memory and means that the values can be called up only as long as the TCM is supplied with power and the sensor is in display FREEZE.

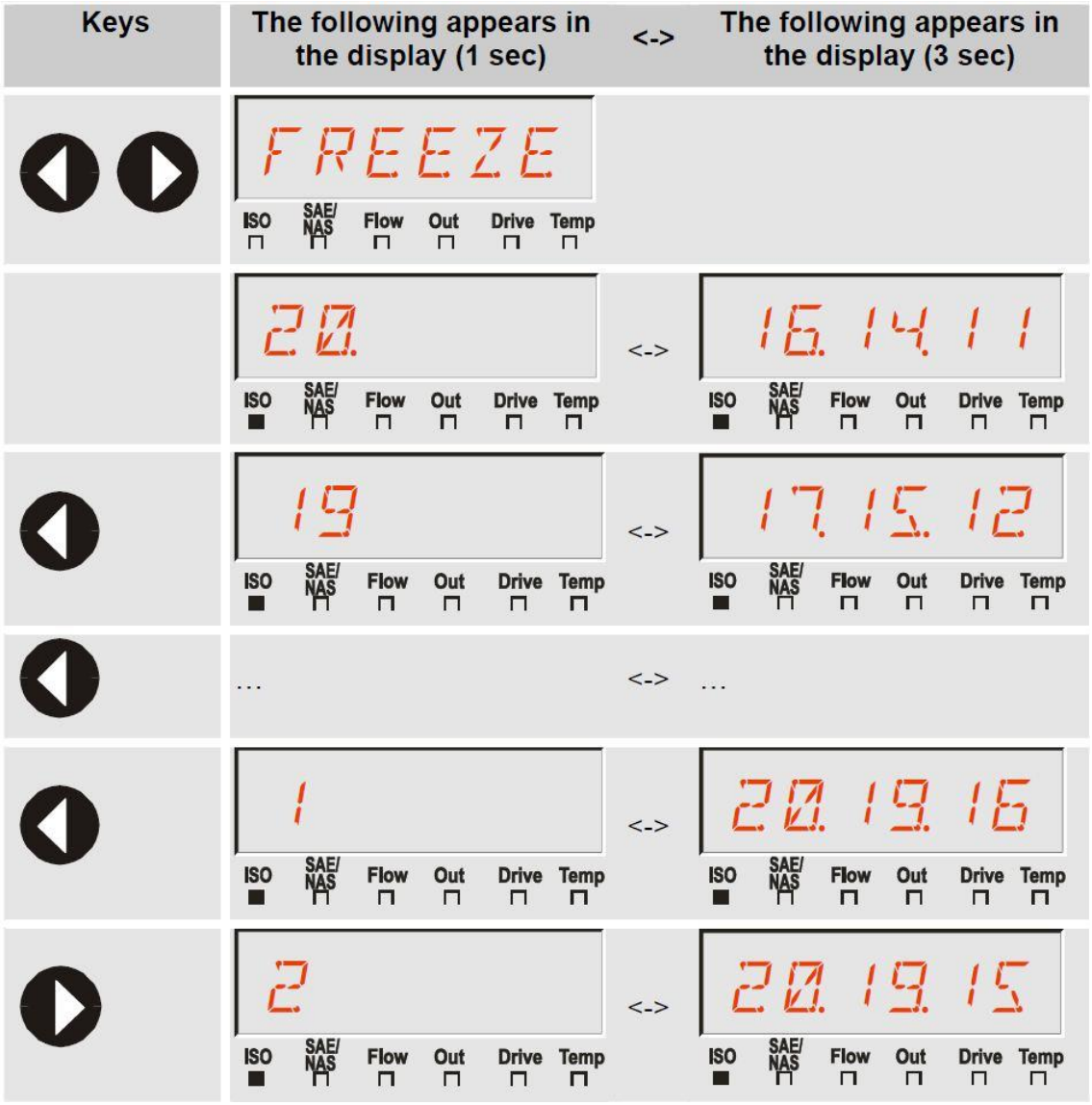
The measured values are automatically numbered, whereby the highest incremental number represents the last measured value. That means that when the memory is full (20 measured values), the value 20 is the most recent and the value 1 is the oldest .

If the memory exceeds 20 display values, the oldest entry will be overwritten.

Activate display FREEZE

To activate or deactivate the history memory FREEZE, press both keys simultaneously.

The FREEZE function starts with the display of the most recent measured value.



Deactivate display FREEZE

If display FREEZE is set to MANUAL in the PowerUp menu:

Press the following two keys simultaneously to return to the current display:

	The display switches to the preset display. All values present in the FREEZE memory are deleted.

If the display FREEZE is set to TIMEOUT in the PowerUp menu:

You are returned automatically to the current display after 10 times the value for MTIME, or manually by pressing both arrow keys simultaneously.

The factory setting of MTIME is 60 seconds x 10 = 600 seconds = 10 minutes.

Menus and modes

The sensor has the following two operating levels / menus.

Menus	Mode	Description	Page
PowerUp Menu	PowerUp Mode	You carry out the basic settings in this menu.	30
Measuring Menu	Measurement mode	This menu starts automatically after powering up.	32 / 36

PowerUp Menu

You can carry out the basic settings for operation of the TCM in the PowerUp menu.

Selection	To do
Start the PowerUp menu	Press any key while the supply voltage to the sensor is switched on / generated.
Exit the PowerUp menu without saving	Scroll through to **CANCEL** and press the o.k. -key. If a key is not pressed within 30 seconds, the system jumps back automatically.
Exit the PowerUp menu after saving.	Scroll through to **SAVE** and press the o.k. -key.

PowerUp Menu:	◀ ▶	Description
	MODE	*Select measurement mode*
	mTIME	*Set measuring duration*
	pPRTCT	*Set pump protection time*
	ADRESS	*Set bus address*
	CALIB	*Select calibration (only 13xx)*
	FREEZE	*Set history memory*
	DFAULT	*Reset TCM to factory default settings*
	CANCEL	*Discard changes and exit*
	SAVE	*Save changes and exit*
	CODE	*For internal use only*

MODE	Select measurement mode	⊕ ⊖	**Description**
		M1	*Continuous measurement*
		M2	*Continuous measurement and switching*
		M3	*Filter to cleanliness class and stop*
		M4	*Filter with continuous monitoring*
		SINGLE	*Single measurement*

mTIME	Set measuring duration	◀ ▶ ⊕ ⊖	**Description**
		60	*Set measuring duration (10 ... 300 seconds)*

pPRTCT	Set pump protection time	⊕ ⊖	**Description**
		0	*0 ... 10 number of measurement cycles.* *Please note that the pump can run dry with an M.TIME setting of 300 * 10 = 3000 seconds = 50 minutes.*

ADRESS	Set bus address	◀ ▶	⊕ ⊖	**Description**
		HECOM		
			A	*(a,b, … z)*
		IP		
			NO SET	
		MODBUS		
			NO SET	

CALIB	Select calibration	◀ ▶	*Available for model TCM 13xx only!*
		ISoSAE	*ISO4406:1999 / SAE*
		ISoNAS	*ISO4406:1987 / NAS*

FREEZE	FREEZE einstellen	◀ ▶

	OFF	*Display function FREEZE switched off*
	Manual	*Return to display manually via the key combination* ◀▶ *See page 23 for details.*
	TIMOUT	*Return to automatic display after 10x the measurement duration M.TIME.*

DFAULT	Resetting to factory setting	*Generate factory setting.* For factory settings see page 85.
CANCEL	Discard changes and exit	
SAVE	Save changes and exit	
CODE	Activates the service menu	*For internal use only*

Measuring Menu (TCM12xx)

During measurement operation, you can perform the following settings:

Selection	To do
Start the measuring menu	Press the o.k. key.
Exit the measuring menu without saving	Scroll through to **CANCEL** and press the o.k. -key. If a key is not pressed within 30 seconds, the system jumps back automatically.
Save and exit the measuring menu	Scroll through to **SAVE** and press the o.k. -key.

Measuring menu:	◀▶	**Description**
	DSPLAY	*Set display*
	SWtOUT	*Configure switching output*
	ANaOUT	*Set analog output - output signal*
	CANCEL	*Discard changes and exit*

	SAVE	*Save changes and exit*

DSPLAY - Display after sensor is switched on

DSPLAY	*Set start display*	⊕ ⊖	**Description**
		ISO	*3-digit ISO code*
		SAE A	*SAE class A*
		SAE B	*SAE class B*
		SAE C	*SAE class C*
		SAE D	*SAE class D*
		SAeMAX	*SAE A-D*
		FLOW	*Flow rate range*
		ANaOUT	*Analog output in mA*
		DRIVE	*LED current in %*
		TEMP C	*Fluid temperature in °C*
		TEMP F	*Fluid temperature in °F*

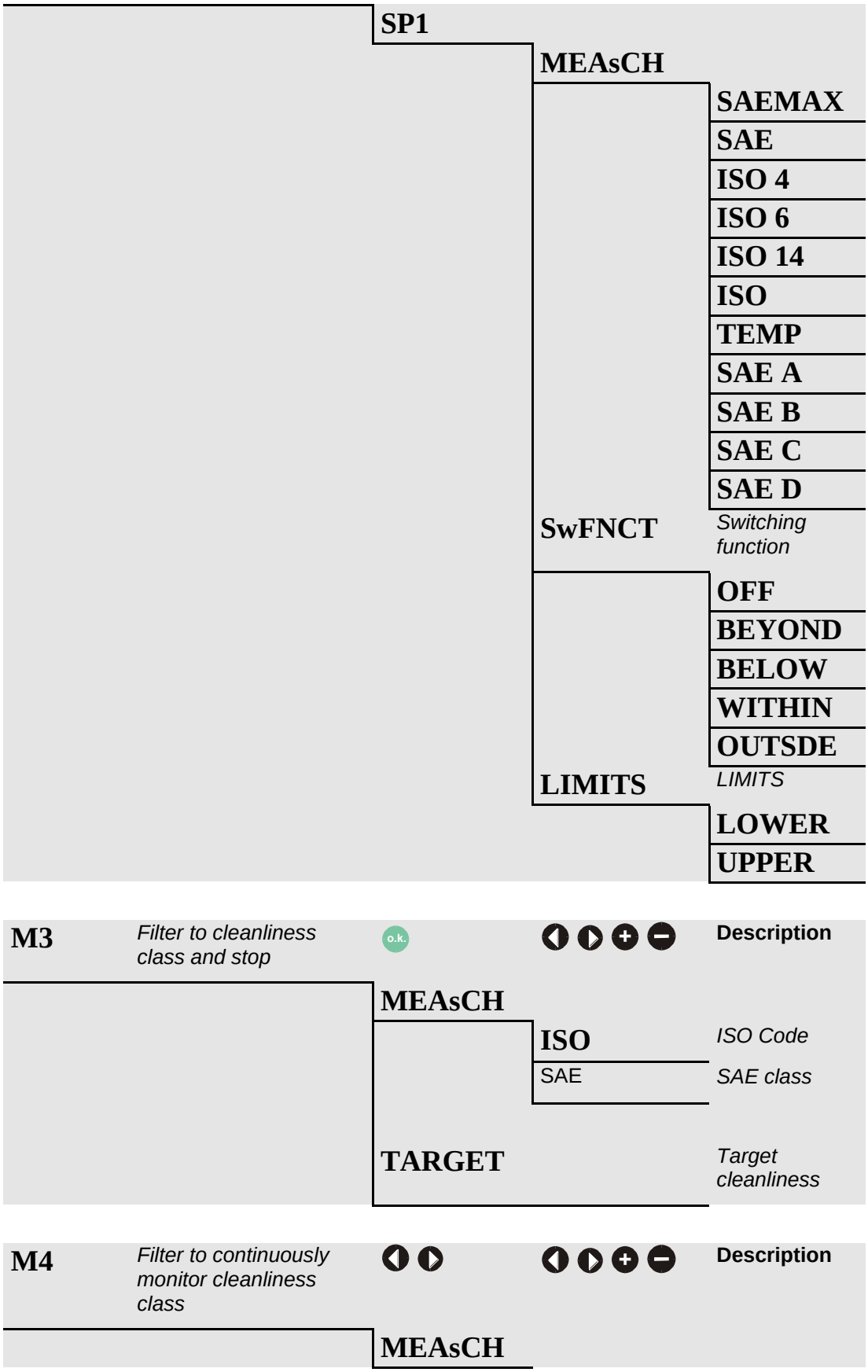
SWT.OUT – Schaltausgang konfigurieren

Here you can adjust the behavior of the switching output. The measurement mode "M1 / M2 / M3 / M4 / SINGLE" is copied from the setting in the PowerUp menu and can no longer be selected here.

SWtOUT	*Configure switching output*	o.k.	**Description**
		M1	*Continuous measurement*
		M2	*Continuous measurement and switching*
		M3	*Filter to cleanliness class and stop*
		M4	*Filter to continuously monitor cleanliness class*
		SINGLE	*Start single measurement + stop*

M1	*Continuous measurement*	o.k.
		NO SET

M2	*Continuous measurement and switching*	o.k.	◀ ▶	⊕ ⊖


SP1
MEAsCH
SAEMAX
SAE
ISO 4
ISO 6
ISO 14
ISO
TEMP
SAE A
SAE B
SAE C
SAE D
SwFNCT
Switching function
OFF
BEYOND
BELOW
WITHIN
OUTSDE
LIMITS
LIMITS
LOWER
UPPER
M3
Filter to cleanliness class and stop
o.k.
Description
MEAsCH
ISO
ISO Code
SAE
SAE class
TARGET
Target cleanliness
M4
Filter to continuously monitor cleanliness class
Description
MEAsCH

TARGET		ISO	*ISO Code*
		SAE	*SAE class*
RSTART			*Target cleanliness*
CYCLE			*Resume filtration from this class*
		60	*Set test cycle time (1…1440 minutes)*

SINGLE	*Start single measurement + stop*	o.k.	
		NO SET	

ANA.OUT - Set output signal at analog output

The measured variable set here is output at the analog output (see page 45).

ANaOUT	*Set analog output - output signal*	⊕ ⊖	**Description**
		SAeMAX	*SAE A-D*
		SAE	*SAE class A/B/C/D (coded)*
		SAE+T	*SAE class + temp. (Code)*
		TEMP	*Fluid temperature*
		HDaISO	*ISO for HDA 5500*
		HDaSAE	*SAE for HDA 5500*
		ISO 4	*ISO 4 code*
		ISO 6	*ISO 6 code*
		ISO 14	*ISO 14 code*
		ISO	*ISO 3-digit (coded)*
		ISO+T	*ISO 3-digit + temp. (coded)*
		SAE A	*SAE class A*
		SAE B	*SAE class B*
		SAE C	*SAE class C*
		SAE D	*SAE class D*

CANCEL	Discard changes and exit
SAVE	Save changes and exit

Measuring menu (TCM13xx)

During measurement operation, you can perform the following settings:

Selection	To do
Start Measuring menu	Press the o.k. key.
Scroll to CANCEL and actuate it	Scroll through to **CANCEL** and press the o.k.-key. If a key is not pressed within 30 seconds, the system jumps back automatically.
Exit menu and save changes	Scroll through to **SAVE** and press the o.k.-key.

Measuring menu:	◀ ▶	Description
	DSPLAY	*Select display*
	SWtOUT	*Configure switching output*
	ANAOUT	*Set analog output - output signal*
	CANCEL	*Discard changes and exit*
	SAVE	Save changes and exit

DSPLAY - Display after sensor is switched on

DSPLAY	*Set start display*	⊕ ⊖	Description
		ISO	*3-digit ISO code*
		NAS 2	*NAS class 2*
		NAS 5	*NAS class 5*
		NAS 15	*NAS class 15*
		NAS 25	*NAS class 25*
		NASMAX	*NAS maximum*
		FLOW	*Flow rate range*
		ANaOUT	*Analog output in mA*

DRIVE	*LED current in %*
TEMP C	*Fluid temperature in °C*
TEMP F	*Fluid temperature in °F*

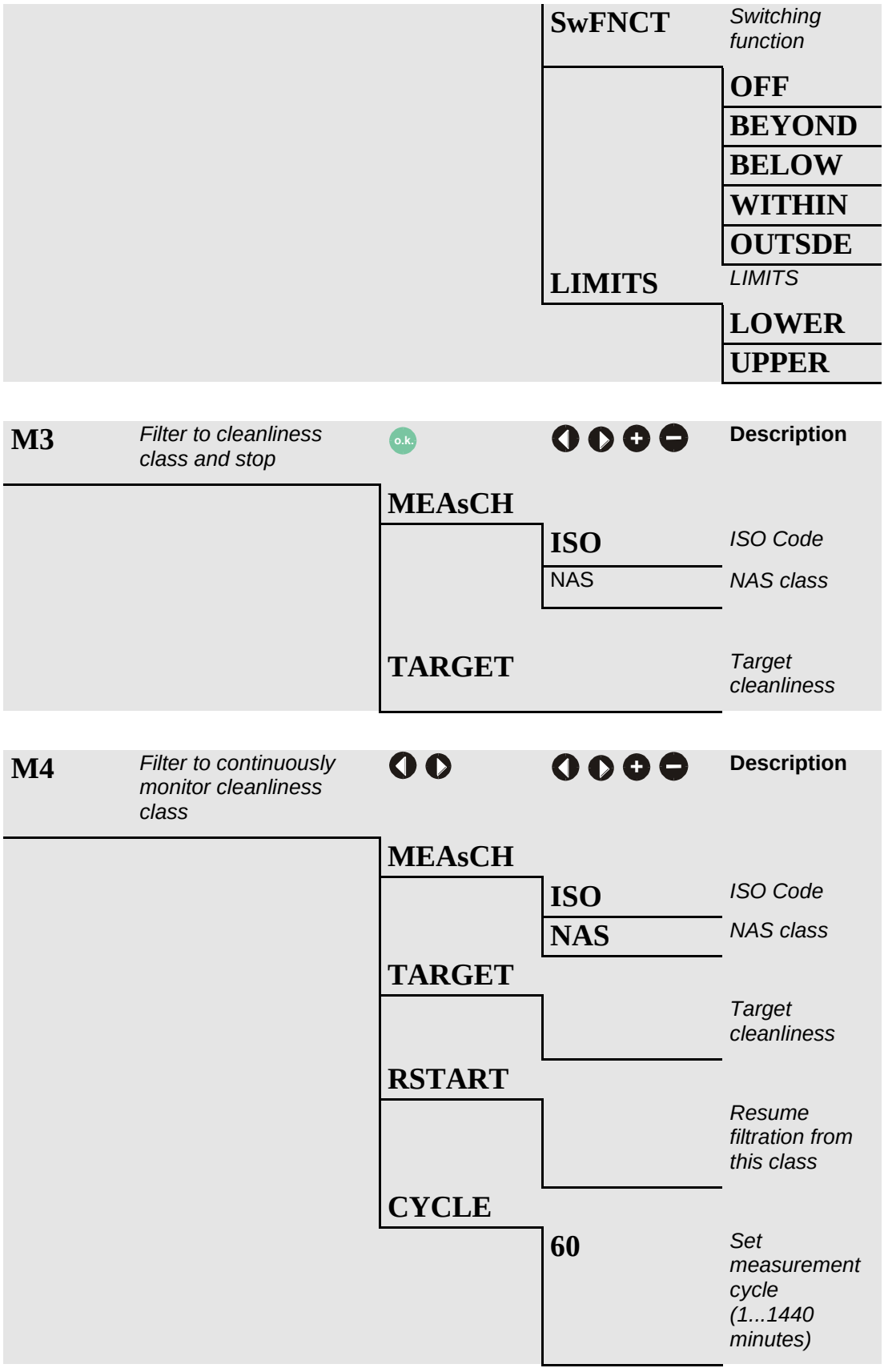
SWT.OUT – Configure switching output

Here you can adjust the behavior of the switching output. The measurement mode "M1 / M2 / M3 / M4 / SINGLE" is copied from the setting in the PowerUp menu and can no longer be selected here.

SWtOUT *Configure switching output*	o.k.	**Description**
	M1	*Continuous measurement*
	M2	*Continuous measurement and switching*
	M3	*Filter to cleanliness class and stop*
	M4	*Filter to continuously monitor cleanliness class*
	SINGLE	*Start single measurement + stop*

M1 *Continuous measurement*	o.k.
	NO SET

M2 *Continuous measurement and switching*	o.k.	◀ ▶	⊕ ⊖
	SP1		
		MEAsCH	
			NAsMAX
			NAS
			ISO 4
			ISO 6
			ISO 14
			ISO
			TEMP
			NAS 2
			NAS 5
			NAS 15
			NAS 25


SwFNCT
Switching function
OFF
BEYOND
BELOW
WITHIN
OUTSDE
LIMITS
LIMITS
LOWER
UPPER
M3
Filter to cleanliness class and stop
o.k.
Description
MEAsCH
ISO
ISO Code
NAS
NAS class
TARGET
Target cleanliness
M4
Filter to continuously monitor cleanliness class
Description
MEAsCH
ISO
ISO Code
NAS
NAS class
TARGET
Target cleanliness
RSTART
Resume filtration from this class
CYCLE
60
Set measurement cycle (1...1440 minutes)

SINGLE	*Start single measurement + stop*	o.k.	
		NO SET	

ANA.OUT - Set output signal at the analog output

The set measured variable is output via the analog output (see page 45).

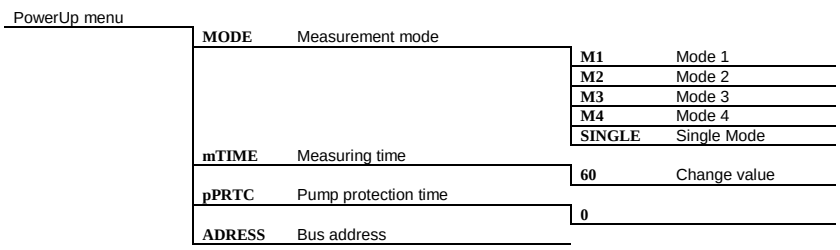
ANaOUT	*Set analog output - output signal*	⊕ ⊖	**Description**
		NAsMAX	*NAS maximum*
		NAS	*NAS class 2/5/15/25 (coded)*
		NAS+T	*NAS class+temp. (coded)*
		TEMP	*Fluid temperature*
		HDaISO	*ISO for HDA 5500*
		HDaNAS	*NAS or SAE for HDA 5500*
		ISO 2	*ISO class 2*
		ISO 5	*ISO class 5*
		ISO 15	*ISO class 15*
		ISO	*ISO 3-digit (coded)*
		ISO+T	*ISO 3-digit + temp. (coded)*
		NAS 2	*NAS class 2*
		NAS 5	*NAS class 5*
		NAS 15	*NAS class 15*
		NAS 25	*NAS class 25*

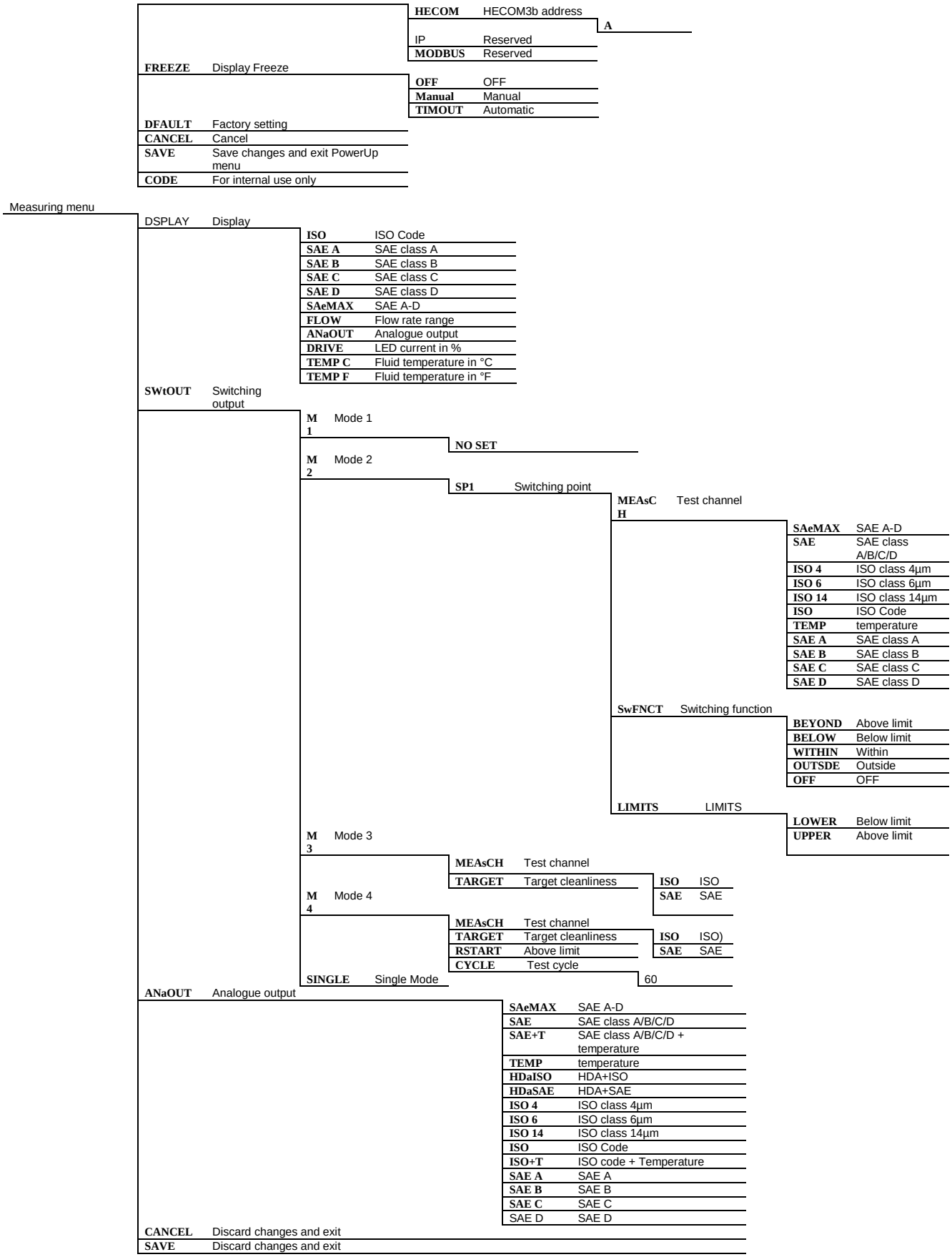
CANCEL	Discard changes and exit

SAVE	Save changes and exit

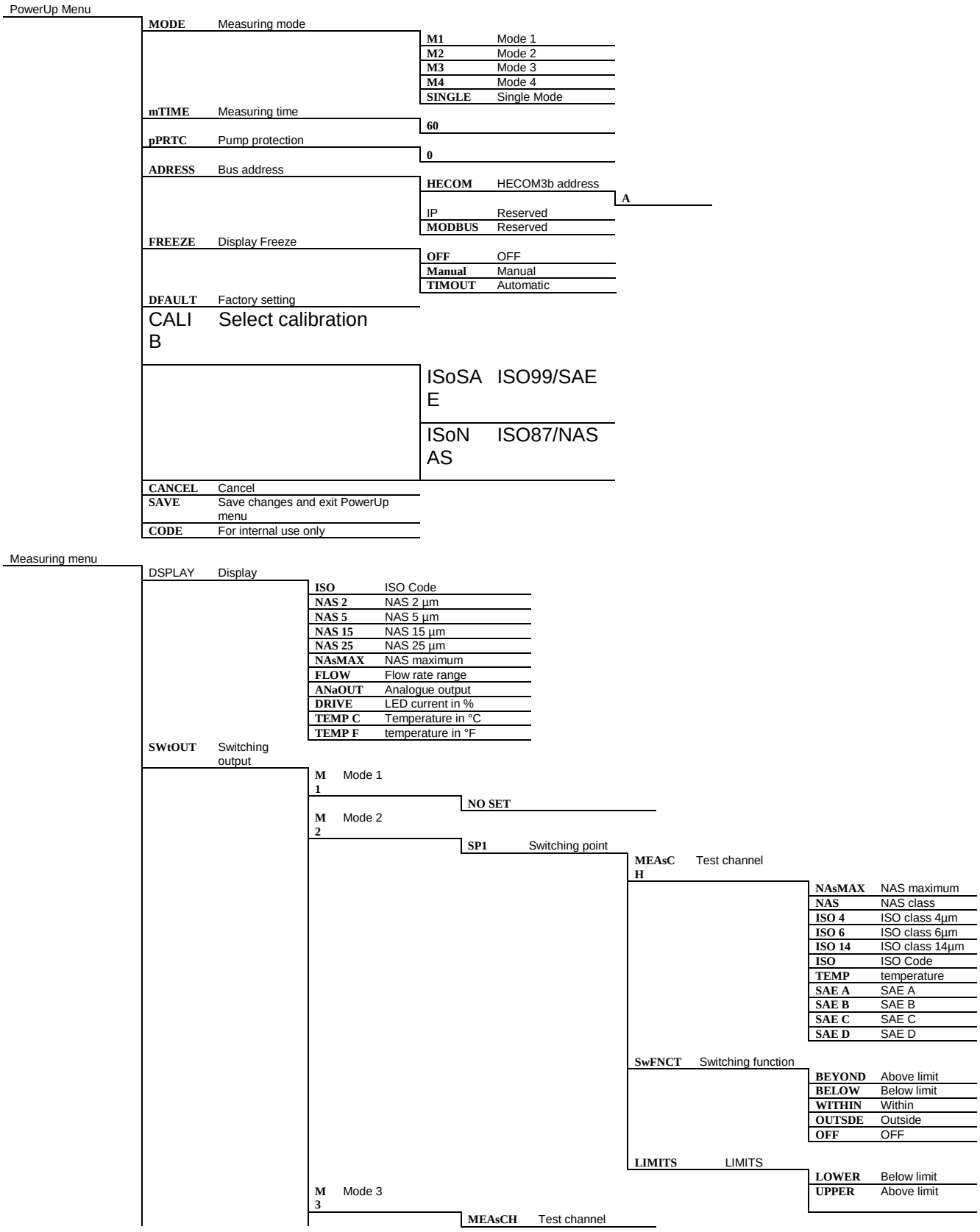
Overview of menu structure

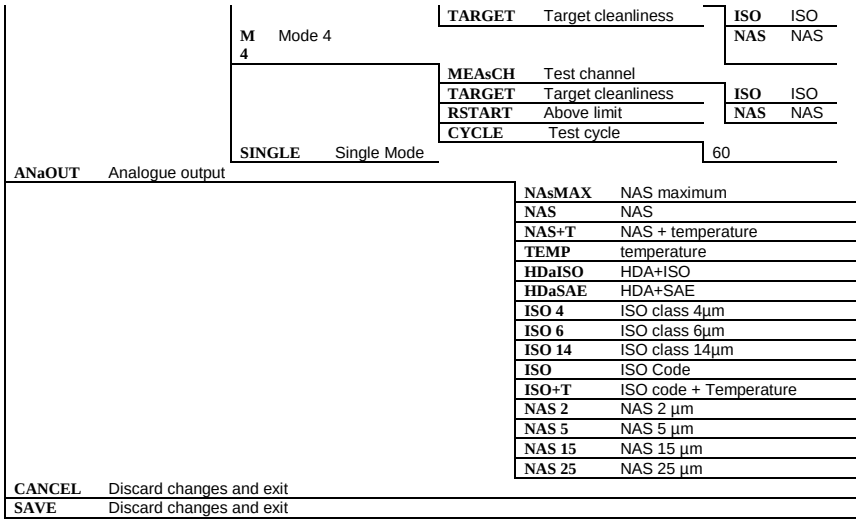
Menu TCM 12xx (ISO 4406:1999 and SAE)




HECOM HECOM3b address
A
IP Reserved
MODBUS Reserved
FREEZE Display Freeze
OFF OFF
Manual Manual
TIMOUT Automatic
DFAULT Factory setting
CANCEL Cancel
SAVE Save changes and exit PowerUp menu
CODE For internal use only
Measuring menu
DSPLAY Display
ISO ISO Code
SAE A SAE class A
SAE B SAE class B
SAE C SAE class C
SAE D SAE class D
SAeMAX SAE A-D
FLOW Flow rate range
ANaOUT Analogue output
DRIVE LED current in %
TEMP C Fluid temperature in °C
TEMP F Fluid temperature in °F
SWtOUT Switching output
M 1 Mode 1
NO SET
M 2 Mode 2
SP1 Switching point
MEAsCH Test channel
SAeMAX SAE A-D
SAE SAE class A/B/C/D
ISO 4 ISO class 4µm
ISO 6 ISO class 6µm
ISO 14 ISO class 14µm
ISO ISO Code
TEMP temperature
SAE A SAE class A
SAE B SAE class B
SAE C SAE class C
SAE D SAE class D
SwFNCT Switching function
BEYOND Above limit
BELOW Below limit
WITHIN Within
OUTSDE Outside
OFF OFF
LIMITS LIMITS
LOWER Below limit
UPPER Above limit
M 3 Mode 3
MEAsCH Test channel
TARGET Target cleanliness
ISO ISO
SAE SAE
M 4 Mode 4
MEAsCH Test channel
TARGET Target cleanliness
ISO ISO)
SAE SAE
RSTART Above limit
CYCLE Test cycle
SINGLE Single Mode
60
ANaOUT Analogue output
SAeMAX SAE A-D
SAE SAE class A/B/C/D
SAE+T SAE class A/B/C/D + temperature
TEMP temperature
HDaISO HDA+ISO
HDaSAE HDA+SAE
ISO 4 ISO class 4µm
ISO 6 ISO class 6µm
ISO 14 ISO class 14µm
ISO ISO Code
ISO+T ISO code + Temperature
SAE A SAE A
SAE B SAE B
SAE C SAE C
SAE D SAE D
CANCEL Discard changes and exit
SAVE Discard changes and exit

Menu TCM 13xx (ISO 4406:1987 and NAS / ISO4406:1999 and SAE 4059 D)





Using switching output

You can use the switching output in the modes described below. For a further description of the measurement modes, see page 22.

Mode M1: Continuous measurement

Purpose: Measurement only

Function: Continuous measurement of cleanliness class Switching function only for "Device ready".

Mode M2: Continuous measurement and switching

Purpose: Continuous measurement and controlling of signal lamps etc.

Function: Continuous measurement of solid contamination, continuous monitoring of programmed limit values; the switching output is enabled and switches on the monitoring display or alarm on site

Mode M3: Filter to cleanliness class and stop

Purpose: Clean up hydraulic reservoir

Function: Control of a filter unit, continuous measurement of solid contamination. If pre-programmed cleanliness level is reached 5 times in sequence, the pump is stopped.

Mode M4: Filter to continuously monitor cleanliness class

Purpose: Establish continuous monitoring of cleanliness class between min/max limit values

Function: If min/max limit values are pre-programmed, the TCM switches the filter unit on/off to keep cleanliness within the limit value range

Load the switching output with a maximum of 2 A and 30 V DC.

Mode "SINGLE" measurement

Purpose: Perform a single measurement and "stop" the result.

Function: Single measurement of solid contamination **without** switching functions
Switching function only for "Device ready".

Setting limit values

The voltage supply to the TCM makes the switching output (SP1) conductive. This condition is maintained for the initial measurement duration (WAIT period). Depending on the measurement mode, the switching output can be used as a Device ready function.

Mode 1 (M1)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
	-	Device ready function Conductive, except in the event of an error
Mode 2 (M2)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
BEYOND Above limit	≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when all values ≤ respective lower limit
BELOW Below limit	≤ lower limit value	After switch-on or start of a measurement. Becomes conductive again when a value ≥ respective upper limit
WITHIN Within limit values	Lower limit ≤ measured value ≤ upper limit	After switch-on or start of a measurement. Becomes conductive again, when a value < respective lower limit or a value > respective upper limit
OUTSDE Outside limit values	Measured value ≤ lower limit or measured value ≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when the respective lower limit < all values < respective upper limit
OFF OFF	-	Conductive, except in the event of an error
Mode 2 (M2) 3-digit ISO code	**Switching output – OPEN**	**Switching output – CONDUCTIVE**

BEYOND Above limit	A value ≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when all values ≤ respective lower limit
BELOW Below limit	All values ≤ lower limit	After switch-on or start of a measurement. Becomes conductive again when a value ≥ respective upper limit
WITHIN Within limit values	Lower limit ≤ all values ≤ upper limit	After switch-on or start of a measurement. Becomes conductive again, when a value < respective lower limit or a value > respective upper limit
OUTSDE Outside limit values	A value ≤ lower limit or A value ≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when the respective lower limit < all values < respective upper limit
OFF No switching function	-	Conductive, except in the event of an error
Mode 3 (M3)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
‾‾‾‾‾	5 consecutive measurements ≤ limit or measurement stopped	Measurement is currently in progress and one or more of the last 5 measured values > limit
Mode 4 (M4)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
Start or result of check measurement after test cycle time: a value ≥ upper limit	For 5 consecutive measurements: all values ≤ lower limit or measurement stopped	Measurement is in progress and during one or more of the last 5 measurements: a value > lower limit
Upon the test cycle time elapsing for the duration of a check measurement	Is open again when all values < upper limit Restart test cycle time	Test cycle time has elapsed
Single Mode **SINGLE**	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
	-	Device ready function Always CONDUCTIVE except in the event of an error

Reading the analog output

Depending on TCM model, the analog output is available as a 4 ... 20 mA or 2 ... 10 V signal.

You can recognize the type of analog output from the model code of the sensor.

TCM Model code	Analogue output
TCM 1 x x x - **A** – x – x – x – x /-xxx	4 … 20 mA
TCM 1 x x x - **B** – x – x – x – x /-xxx	2 … 10 V

Observe the design of the analog output in the order. It is not possible to internally change the analog output over later.

In the measuring menu, select one of the following signals for the analog output:

- SAE classes acc. to AS 4059
- ISO Code acc. to ISO 4406:1999
- ISO code acc. to ISO 4406:1987
- NAS class 1638
- Hydraulic fluid temperature

SAE classes acc. to AS 4059

The following SAE values can be read out via the analog output:

- **SAE A-D (SAEMAX)**

  Only one single value is output.
- **SAE A / B / C / D**

  All values are sequentially time-coded before output.
- **SAE A / SAE B / SAE C / SAE D**

  Only one value is output.
- **SAE+T**

  All values are sequentially time-coded before output.
- **HDA.SAE**

  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal depends on the ISO contamination class acc. to SAE = 0.0 … 14.0 (resolution 0.1 class) or on an error as described below:

Current I	SAE class / Error	Voltage U
I < 4.00 mA	Cable break	U < 2.00 V
4.0 mA < I < 4.1 mA	Device error / The TCM is not ready.	2.00 V < U < 2.05 V
4.1 mA < I < 4.3 mA	Not defined	2.05 V < U < 2.15 V

Current I	SAE class / Error	Voltage U
4.3 mA < I < 4.5 mA	Flow error (The flow rate is too low.)	2.15 V < U < 2.25 V
4.5 mA < I < 4.8 mA	Not defined	2.25 V < U < 2.40 V
I = 4.80 mA	SAE 0	U = 2.4V
…	…	…
I = 19.20 mA	SAE 14.0	U = 9.60V
19.2 mA < I < 19.8 mA	Not defined	9.60 V < U < 9.90 V
19.8 mA < I < 20 mA	No measured value	9.90 V < U < 10 V

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

I = 4.8 mA + SAE class x (19.2 mA - 4.8 mA) / 14

U = 2.4 V + SAE class x (9.6 V - 2.4 V) / 14

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

SAE class = (I - 4.8 mA) x (14/14.4 mA)

SAE class = (U - 2.4 V) x (14/7.2 V)

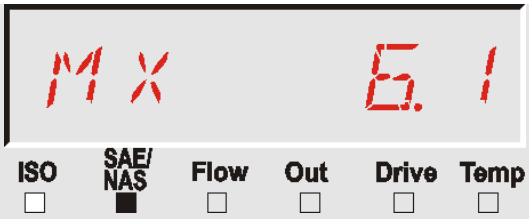
SAE A-D

The **SAeMAX** value is the highest class in any of one of the four SAE A-D classes (respectively >4 $\mu m_{(c)}$,>6 $\mu m_{(c)}$,>14 $\mu m_{(c)}$,>21 $\mu m_{(c)}$).

The signal is updated after the measuring period has elapsed (the measuring period is set in the PowerUp menu, factory setting = 60 s).

The **SAeMAX** signal is output depending on the maximum SAE class.

Example:

SAE classes	SAEMAX (SAE A-D)
SAE 6.1A / 5.7B / 6.0C / 5.5D	

For basic information about cleanliness classes, see page 81 ff.

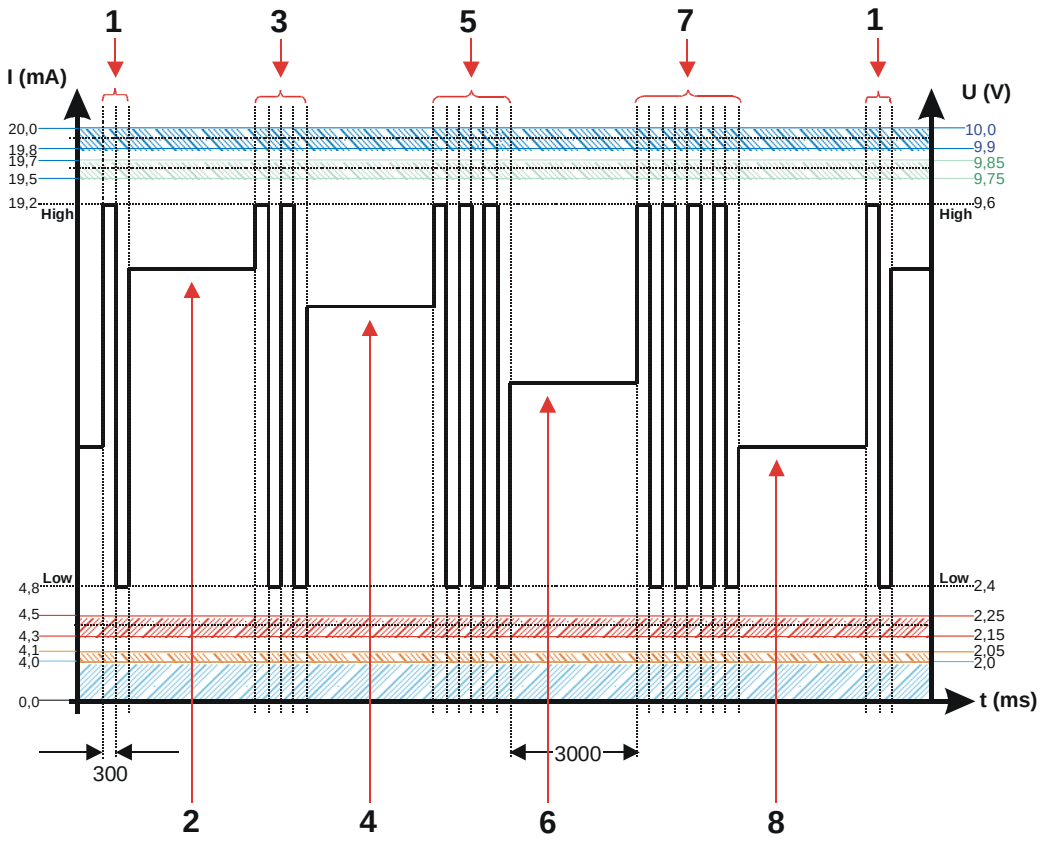
The SAE classification contains integer values only. Better trend recognition is based on a resolution of 0.1 contamination classes as supplied by the TCM 1000.

To convert a decimal value to an integer, the decimal value has to be rounded up.

For example: a readout of SAE 10.7 is, according to SAE 4059 (D), a class SAE 11.

SAE Class A / B / C / D

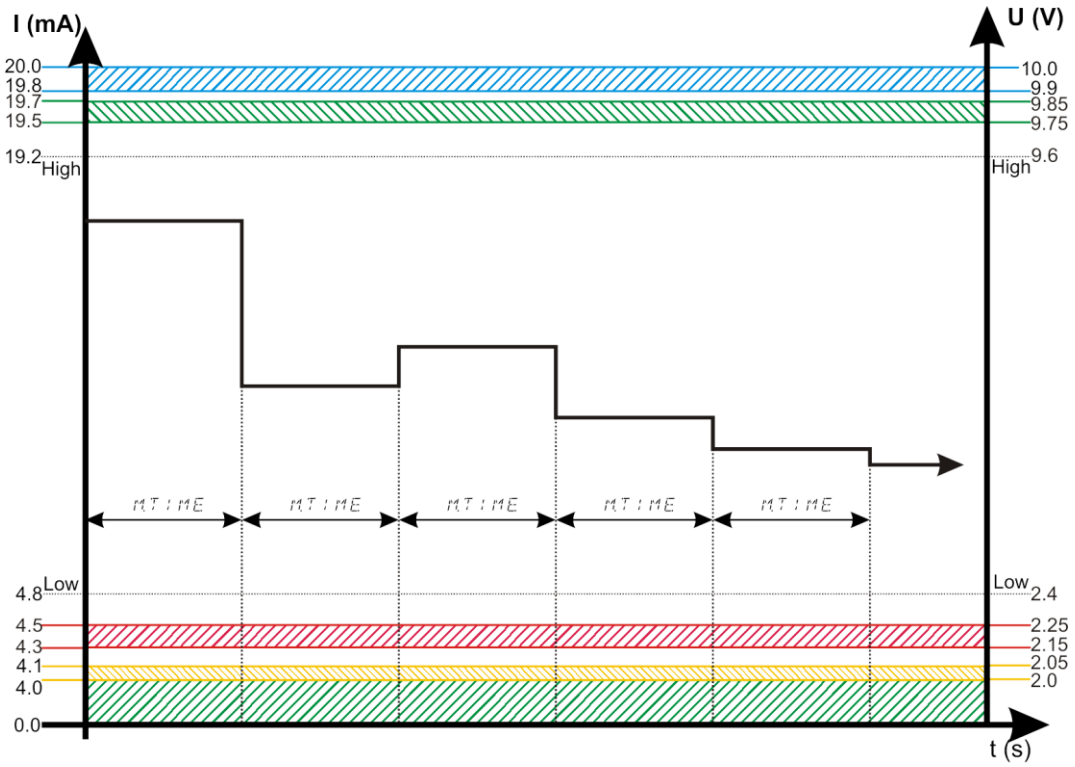
The SAE class A/B/C/D signal consists of 4 measured values transmitted with the following time-coded time slices:



Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	SAE A	300	High / Low
	2	Measured value	SAE A	3000	Current/Voltage for measured value
	3	Identifier	SAE B	300	High / Low / High / Low
	4	Measured value	SAE B	3000	Current/Voltage for measured value
	5	Identifier	SAE C	300	High / Low / High / Low / High / Low
	6	Measured value	SAE C	3000	Current/Voltage for measured value
	7	Identifier	SAE D	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	SAE D	3000	Current/Voltage for measured value

SAE A / SAE B / SAE C / SAE D

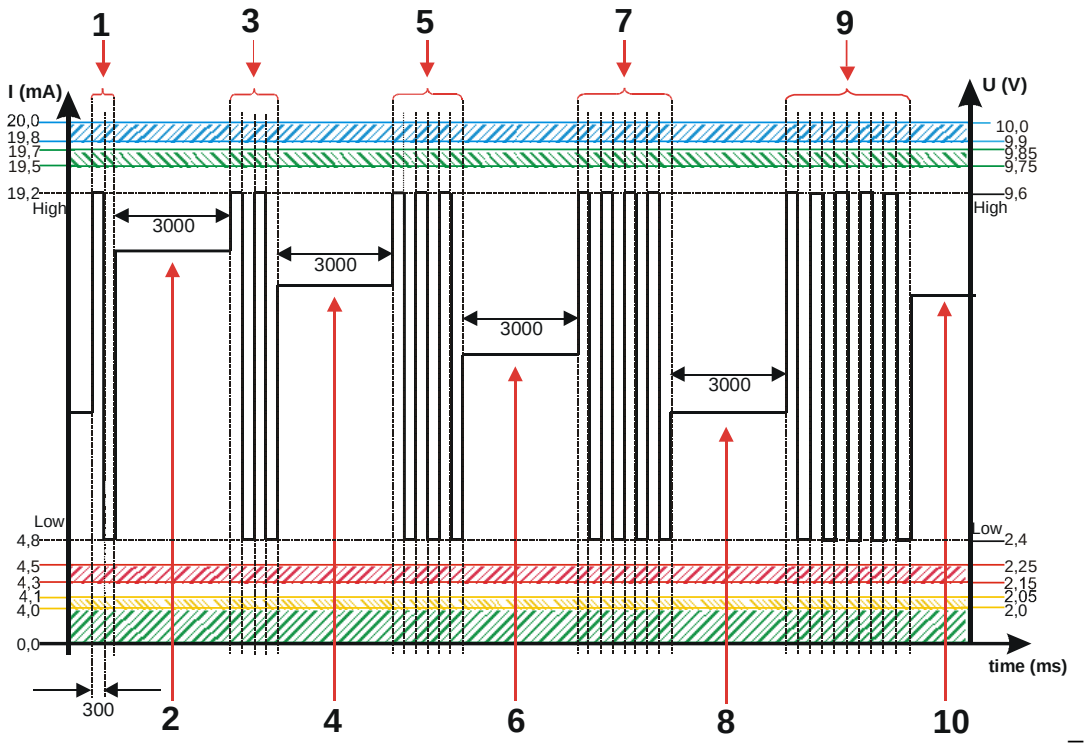
The SAE X signal consists of a measured value (SAE A / SAE B / SAE C / or SAE D) which is permanently transmitted as described in the following.



mTIME = Duration of the measurement as set in the PowerUp menu, see page 30.

SAE + T

The SAE+T signal consists of 5 measured values which are transmitted time-coded with the following time slices:

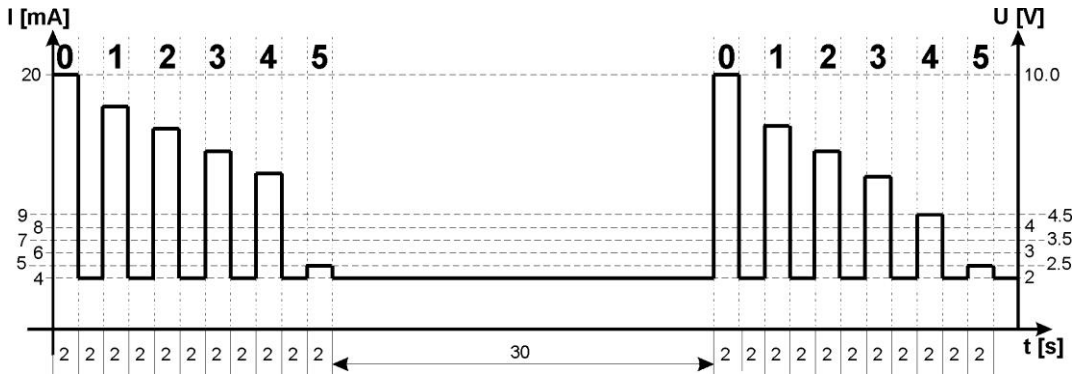


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	SAE A	300	High / Low
	2	Measured value	SAE A	3000	Current/Voltage for measured value
	3	Identifier	SAE B	300	High / Low / High / Low
	4	Measured value	SAE B	3000	Current/Voltage for measured value
	5	Identifier	SAE C	300	High / Low / High / Low / High / Low
	6	Measured value	SAE C	3000	Current/Voltage for measured value
	7	Identifier	SAE D	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	SAE D	3000	Current/Voltage for measured value
	9	Identifier	temperature	300	High / Low / High / Low / High / Low / High / Low / High / Low
	10	Measured value	temperature	3000	Current/Voltage for measured value

HDA.SAE – Analog signal SAE to the HDA 5500

The HDA.SAE signal consists of 6 values (START / SAE A / SAE B / SAE C / SAE D / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	SAE A	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	SAE B	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	SAE C	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	SAE D	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current / Voltage for signal
	Pause		30	4 mA / 2 V

HDA.SAE Signal 1/2/3/4

The current or voltage range is dependent on the contamination class according to SAE=0.0 – 14.0 (resolution 0.1 class).

Current I	SAE class / Error	Voltage U
I < 4.00 mA	Cable break	U< 2.00 V
I = 4.00 mA	SAE 0	U = 2.00V
…	…	…
I = 20.00 mA	SAE 14.0	U = 10.00V

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

$$I = 4\ mA + SAE\ class \times (20\ mA - 4\ mA) / 14$$

$$U = 2\ V + SAE\ class \times (10\ V - 2\ V) / 14$$

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

$$SAE\ class = (I - 4\ mA) \times (14/16\ mA)$$

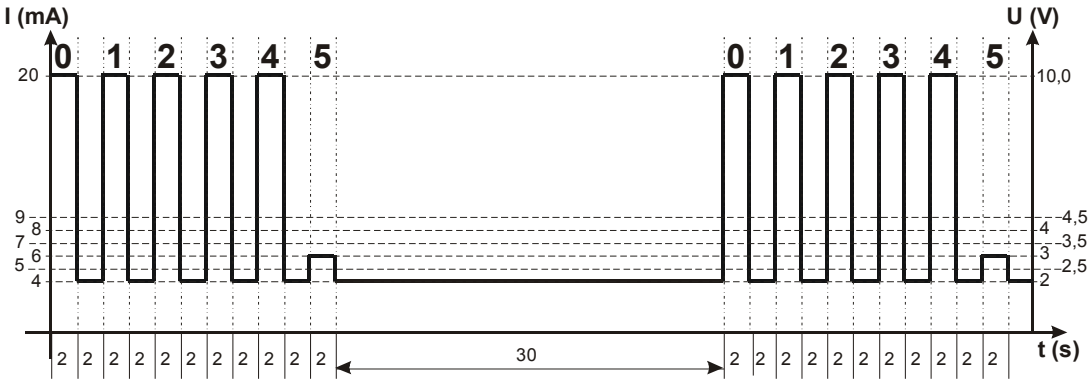
$$SAE\ class = (U - 2\ V) \times (14/8\ V)$$

HDA.SAE signal 5 (status)

The current or voltage of the output signal (5) is dependent on the status of the TCM as shown in the table below:

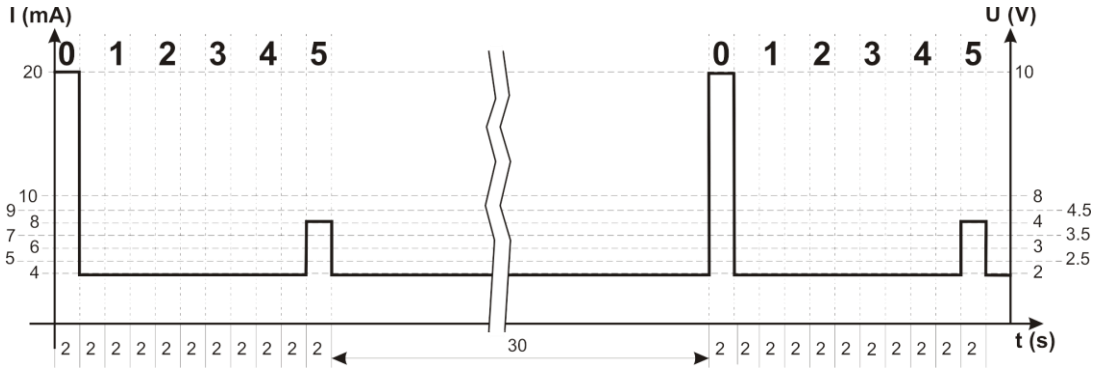
Current I	Status	Voltage U
I = 5.0 mA	The TCM is functioning correctly.	U = 2.5V
I = 6.0 mA	Device error / The TCM is not ready.	U = 3.0V
I = 7.0 mA	The flow rate is too low.	U = 3.5V
I = 8.0 mA	SAE < 0	U = 4.0V
I = 9.0 mA	No measured value (The flow rate is not defined.)	U = 4.5V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	Current I	Voltage U	SAE class
1	4.0 mA	2.0 V	0
2	4.0 mA	2.0 V	0
3	4.0 mA	2.0 V	0
4	4.0 mA	2.0 V	0



ISO code acc. to ISO 4406:1999

The following ISO values can be read out via the analog output:

- **ISO 4 / ISO 6 / ISO 14**

  Only one value is output.

- **ISO code in 3 figures (>4µm$_{(c)}$ / >6µm$_{(c)}$ / >14µm$_{(c)}$)**

  All values are sequentially time-coded before output.

- **ISO+T**

  All values are sequentially time-coded before output.

- **HDA.ISO**

  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal depends on the ISO contamination class 0.0 … 24.28 (resolution 1 class) or on an error as described below:

Current I	ISO code / error	Voltage U
I < 4.0 mA	Cable break	U< 2.0 V
4.0 mA < I < 4.1 mA	Device error / The TCM is not ready.	2.0 V < U < 2.05 V
4.1 mA < I < 4.3 mA	Not defined	2.05 V < U < 2.15 V
4.3 mA < I < 4.5 mA	Flow error (The flow rate is too low.)	2.15 V < U < 2.25 V
4.5 mA < I < 4.8 mA	Not defined	2.25 V < U < 2.4 V
I = 4.80 mA	ISO 0	U = 2.40V
…	…	…
I = 19.20 mA	ISO 24.28	U = 9.60V
19.2 mA < I < 19.8 mA	Not defined	9.60 V < U < 9.90 V
19.8 mA < I < 20 mA	No measured value	9.90 V < U < 10 V

The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:

I = 4.8 mA + ISO code x (19.2 mA - 4.8 mA) / 24.28

U = 2.4 V + ISO Code x (9.6 V - 2.4 V) / 24.28

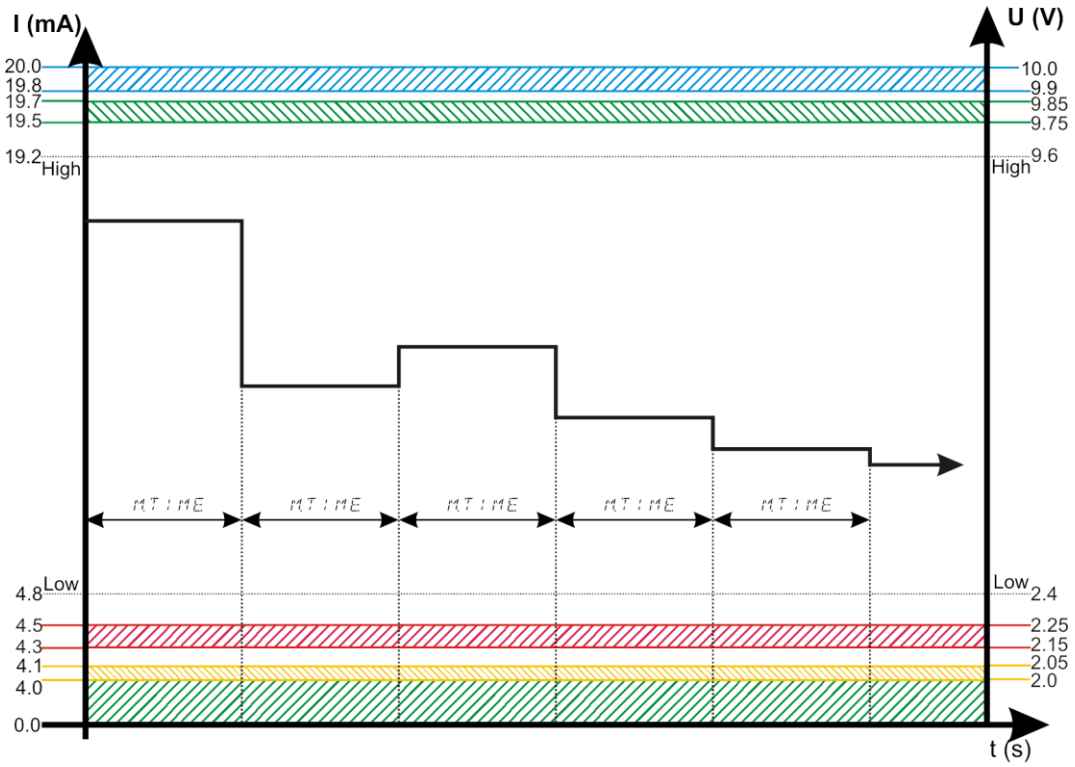
The ISO contamination class can be calculated for a given current I or voltage U as follows:

ISO code = (I - 4.8 mA) x (24.28 / 14.4 mA)

ISO code = (U - 2.4 V) x (24.28 / 7.2 V)

ISO 4 / ISO 6 / ISO 14

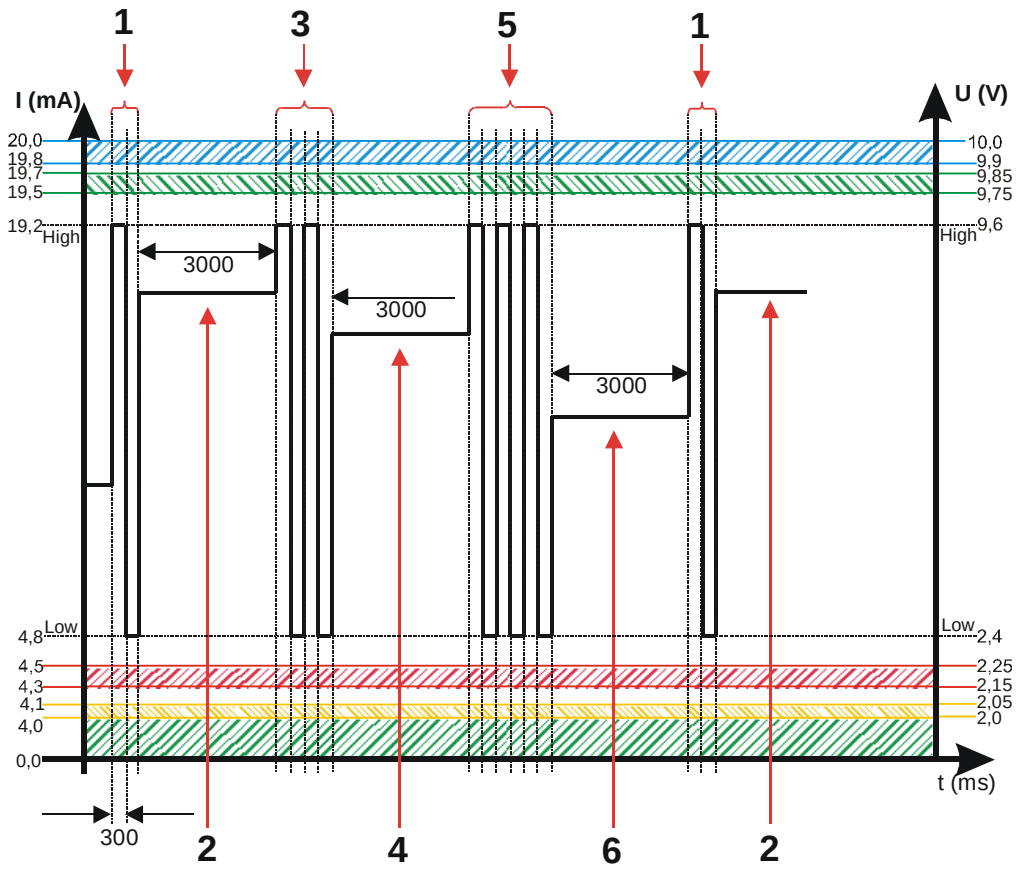
The ISO X signal consists of a measured value (> 4 µm or > 6 µm or > 14 µm) which is permanently transmitted, as described below.



mTIME = Duration of the measurement as set in the PowerUp menu, see page 30.

ISO code, 3-digit

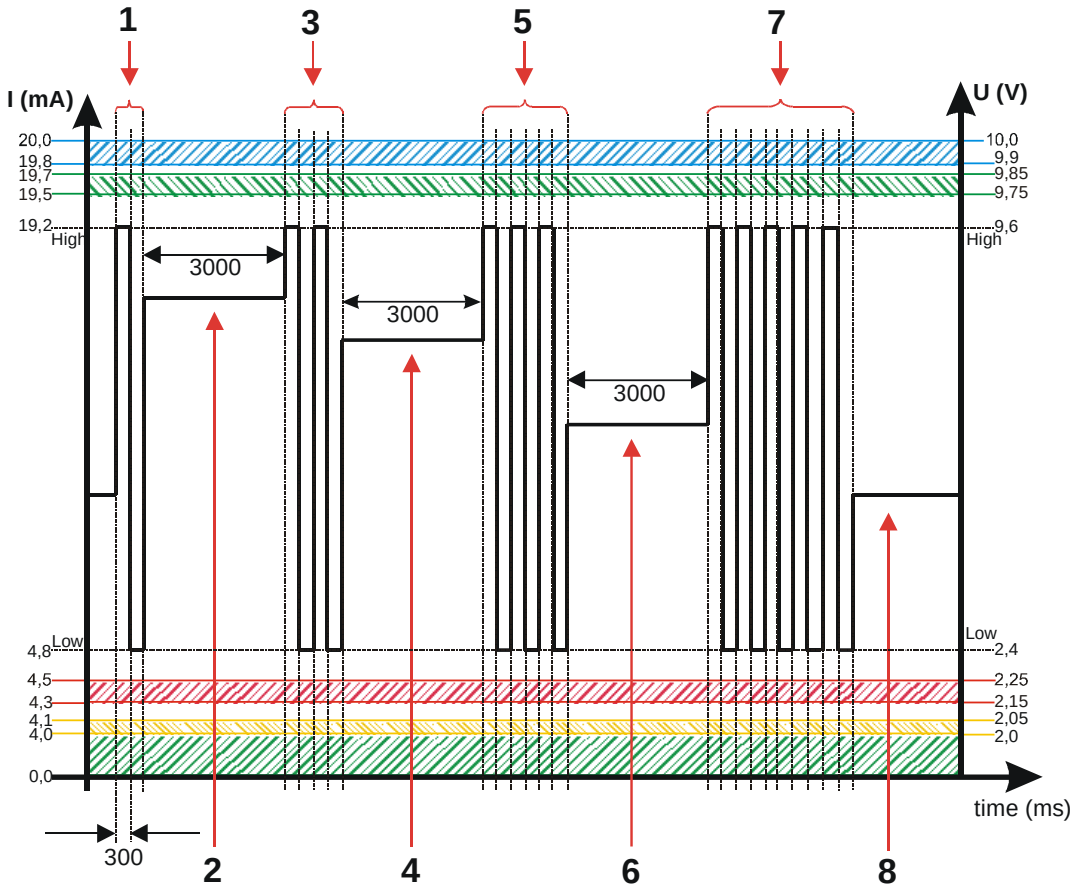
The ISO code signal consists of 3 measured values (>4µm$_{(c)}$ / >6µm$_{(c)}$ / >14µm$_{(c)}$) which are transmitted time-coded.



Time			Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>4µm$_{(c)}$	300	High / Low
	2	Measured value	>4µm$_{(c)}$	3000	Current/Voltage for measured value
	3	Identifier	>6µm$_{(c)}$	300	High / Low / High / Low
	4	Measured value	>6µm$_{(c)}$	3000	Current/Voltage for measured value
	5	Identifier	>14µm$_{(c)}$	300	High / Low / High / Low / High / Low
	6	Measured value	>14µm$_{(c)}$	3000	Current/Voltage for measured value

ISO + T

The ISO+T signal consists of 4 measured values which are transmitted time-coded with the following time slices:

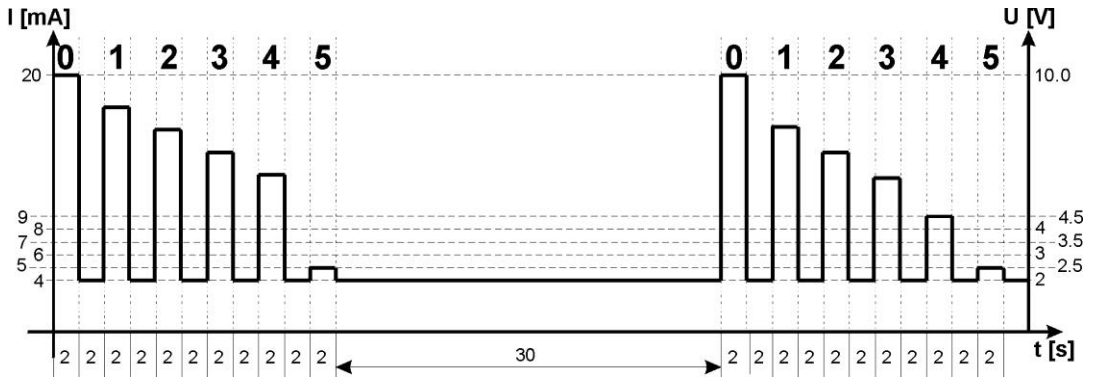


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>4µm$_{(c)}$	300	High / Low
	2	Measured value	>4µm$_{(c)}$	3000	Current/Voltage for measured value
	3	Identifier	>6µm$_{(c)}$	300	High / Low / High / Low
	4	Measured value	>6µm$_{(c)}$	3000	Current/Voltage for measured value
	5	Identifier	>14µm$_{(c)}$	300	High / Low / High / Low / High / Low
	6	Measured value	>14µm$_{(c)}$	3000	Current/Voltage for measured value
	7	Identifier	temperature	300	High / Low / High / Low / High / Low / High / Low / High / Low
	8	Measured value	temperature	3000	Current/Voltage for measured value

HDA.ISO – Analog signal ISO to HDA 5500

The HDA.ISO signal consists of 6 measured values (START / ISO 4 / ISO 6 / ISO 14 / ISO 21 / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	ISO 4	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	ISO 6	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	ISO 14	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	ISO 21	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current / Voltage for signal
	Pause		30	4 mA / 2 V

HDA.ISO Signal 1/2/3/4

The current 4 … 20 mA or voltage 2 … 10 V of the output signal depends on the ISO contamination class 0.0 … 24.28 (resolution 1 class) as described below:

Current I	ISO Code	Voltage U
I < 4.00 mA	Cable break	U < 2.00 V
I = 4.00 mA	ISO 0	U = 2.00V
…	…	…
I = 20.00 mA	ISO 24.28	U = 10.0V

The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:

I = 4 mA + ISO code x (20 mA - 4 mA) / 24.28

U = 2 V + ISO Code x (10 V - 2 V) / 24.28

The ISO contamination class can be calculated for a given current I or voltage U as follows:

ISO code = (I - 4 mA) x (24.28 / 16 mA)

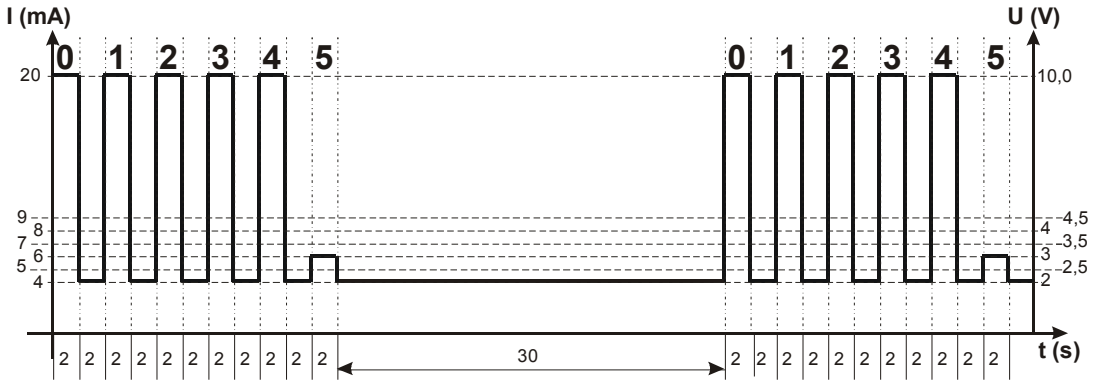
ISO code = (U - 2 V) x (24.28 / 8 V)

HDA.ISO signal 5 (status)

The current or voltage of the output signal (5) is dependent on the status of the TCM as shown in the table below:

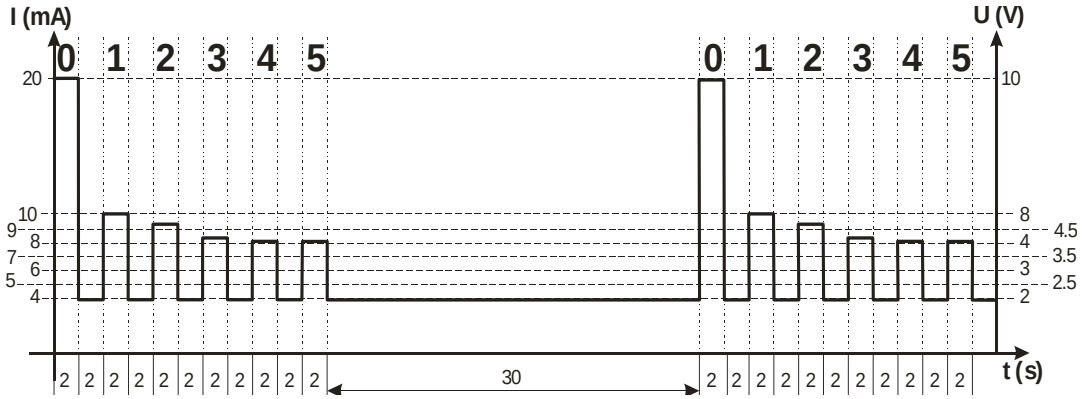
Current I	Status	Voltage U
I = 5.0 mA	The TCM is functioning correctly.	U = 2.5V
I = 6.0 mA	Device error / The TCM is not ready.	U = 3.0V
I = 7.0 mA	The flow rate is too low.	U = 3.5V
I = 8.0 mA	ISO <9.<8.<7	U = 4.0V
I = 9.0 mA	No measured value (The flow rate is not defined.)	U = 4.5V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	Current I	Voltage U	ISO value
1	9.93 mA	4.97 V	9
2	9.27 mA	4.64 V	8
3	8.61 mA	4.31 V	7
4	7.95 mA	3.98 V	6



ISO code signal acc. to ISO 4406:1987 (TCM 13xx only)

The following ISO values can be read out via the analog output:

- **ISO 2 / ISO 5 / ISO 15**

  Only one value is output.

- **ISO code in 3 figures (>2µm$_{(c)}$ / >5µm$_{(c)}$ / >15µm$_{(c)}$)**

  All values are sequentially time-coded before output.

- **ISO+T**

  All values are sequentially time-coded before output.

- **HDA.ISO**

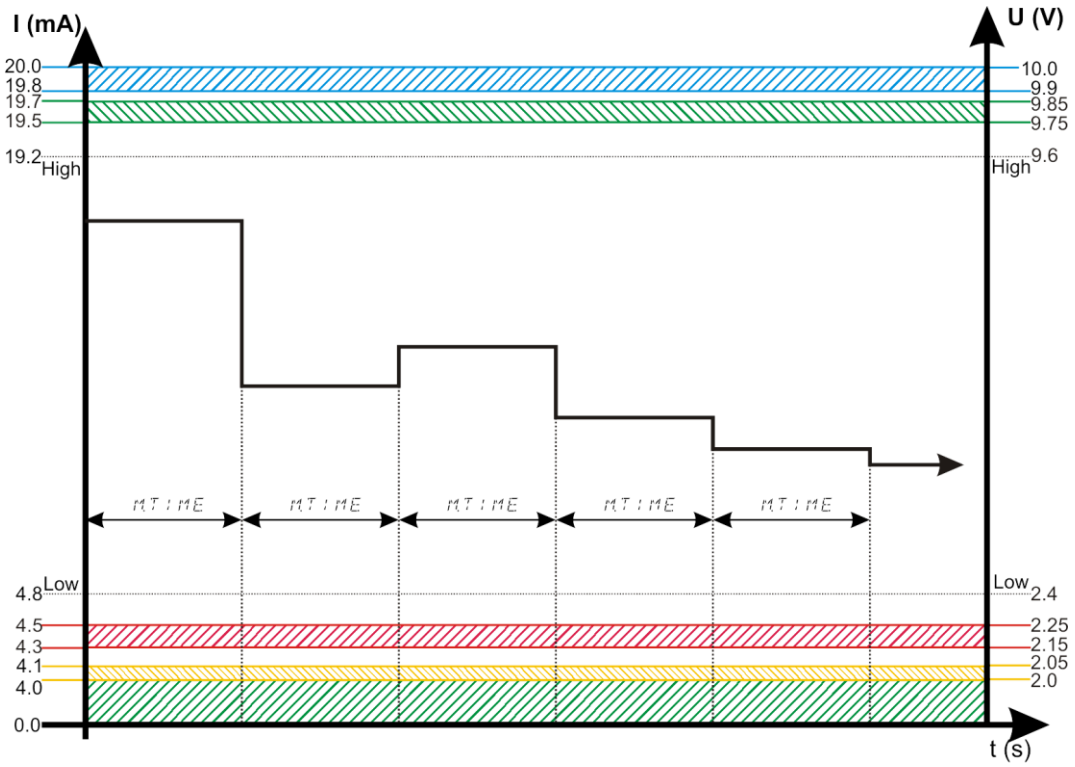
  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal depends on the ISO contamination class 0.0 … 24.28 (resolution 1 class) or on an error as described below:

Current I	ISO code / error	Voltage U
I < 4.00 mA	Cable break	U < 2.00 V
4.0 mA < I < 4.1 mA	Device error / The TCM is not ready.	2.0 V < U < 2.05 V
4.1 mA < I < 4.3 mA	Not defined	2.05 V < U < 2.15 V
4.3 mA < I < 4.5 mA	Flow error (The flow rate is too low.)	2.15 V < U < 2.25 V
4.5 mA < I < 4.8 mA	Not defined	2.25 V < U < 2.4 V
I = 4.80 mA	ISO 0	U = 2.40V
…	…	…
I = 19.20 mA	ISO 24.28	U = 9.60V
19.2 mA < I < 19.8 mA	Not defined	9.60 V < U < 9.90 V
19.8 mA < I < 20 mA	No measured value	9.90 V < U < 10 V
The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:		
I = 4.8 mA + ISO code x (19.2 mA - 4.8 mA) / 24.28		
U = 2.4 V + ISO Code x (9.6 V - 2.4 V) / 24.28		
The ISO contamination class can be calculated for a given current I or voltage U as follows:		
ISO code = (I - 4.8 mA) x (24.28 / 14.4 mA)		
ISO code = (U - 2.4 V) x (24.28 / 7.2 V)		

ISO 2 / ISO 5 / ISO 15

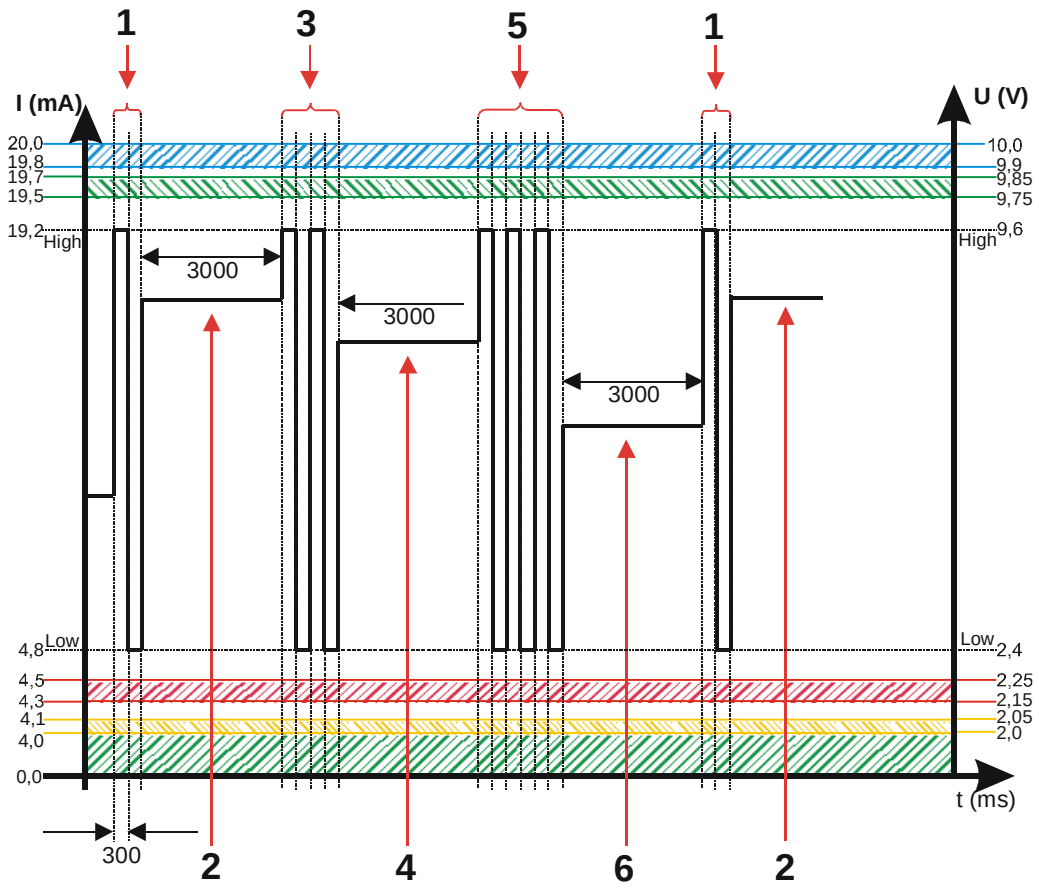
The ISO X signal consists of a measured value (> 2 µm or > 5 µm or > 15 µm) which is permanently transmitted, as described in the following.



mTIME = Duration of the measurement as set in the PowerUp menu, see page 30.

ISO code, 3-digit

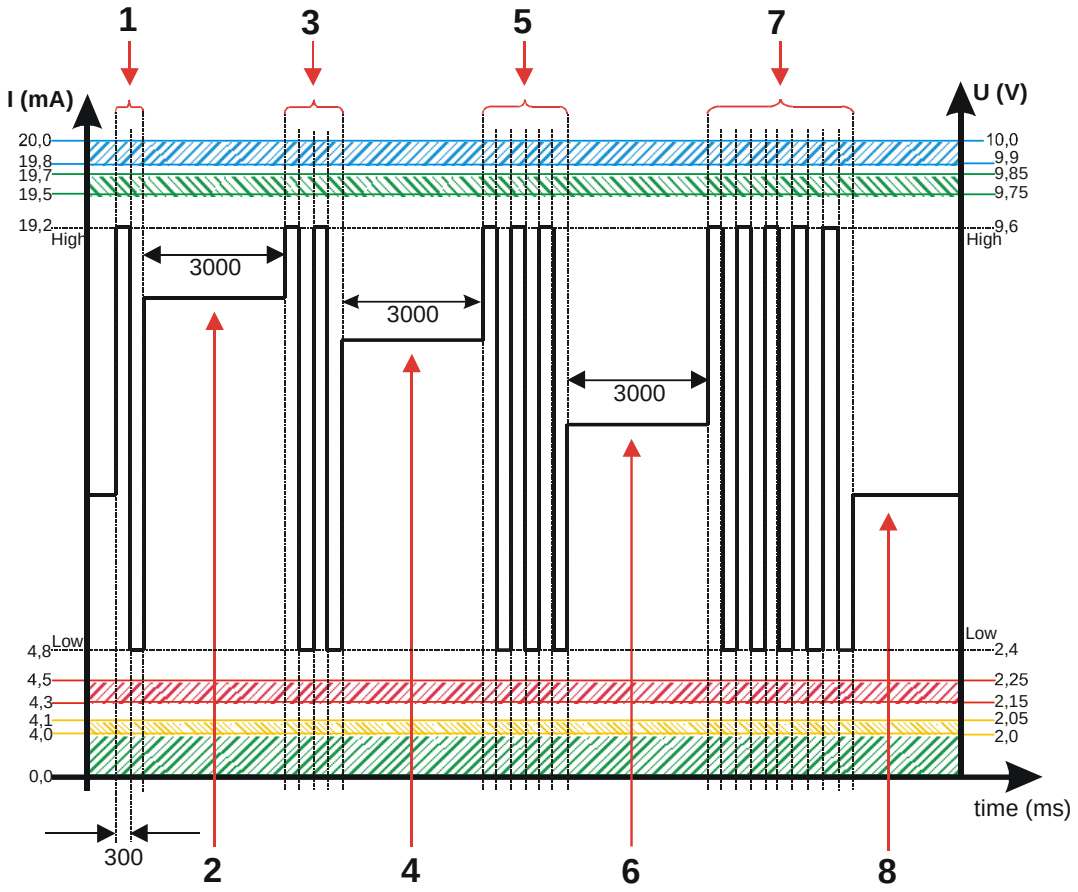
The ISO code signal consists of 3 measured values (>2 µm / >5 µm / >15 µm) which are transmitted time-coded as shown below.



Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>2µm	300	High / Low
	2	Measured value	>2µm	3000	Current/Voltage for measured value
	3	Identifier	>5µm	300	High / Low / High / Low
	4	Measured value	>5µm	3000	Current/Voltage for measured value
	5	Identifier	>15µm	300	High / Low / High / Low / High / Low
	6	Measured value	>15µm	3000	Current/Voltage for measured value

ISO + T

The ISO+T signal consists of 4 measured values which are transmitted time-coded with the following time slices:

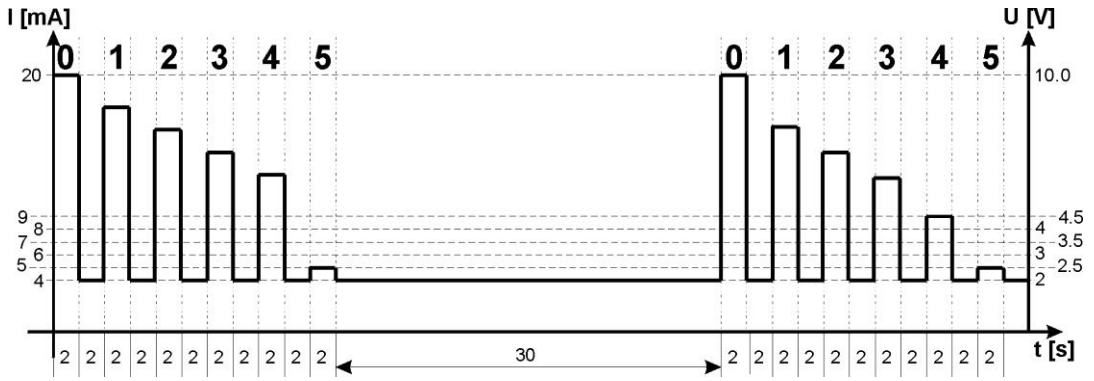


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>2µm	300	High / Low
	2	Measured value	>2µm	3000	Current/Voltage for measured value
	3	Identifier	>5µm	300	High / Low / High / Low
	4	Measured value	>5µm	3000	Current/Voltage for measured value
	5	Identifier	>15µm	300	High / Low / High / Low / High / Low
	6	Measured value	>15µm	3000	Current/Voltage for measured value
	7	Identifier	temperature	300	High / Low / High / Low / High / Low / High / Low / High / Low
	8	Measured value	temperature	3000	Current/Voltage for measured value

HDA.ISO – Analog signal ISO to HDA 5500

The HDA.ISO signal consists of 4 measured values (ISO 4 / ISO 6 / ISO 14 / ISO 21 / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	> 4 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	> 6 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	> 14 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	> 21 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current/voltage for signal
	Pause		30	4 mA / 2 V

HDA.ISO Signal 1/2/3/4

The current 4 … 20 mA or voltage 2 … 10 V of the output signal depends on the ISO contamination class 0.0 … 24.28 (resolution 1 class) as described below:

Current I	ISO Code	Voltage U
I < 4.00 mA	Cable break	U < 2.00 V
I = 4.00 mA	ISO 0	U = 2.00V
…	…	…
I = 19.82 mA	ISO 24	U = 9.90V
I = 20.00 mA	ISO 24.28	U = 10.0V

The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:

I = 4 mA + ISO code x (20 mA - 4 mA) / 24.28

U = 2 V + ISO Code x (10 V - 2 V) / 24.28

The ISO contamination class can be calculated for a given current I or voltage U as follows:

ISO code = (I - 4 mA) x (24.28 / 16 mA)

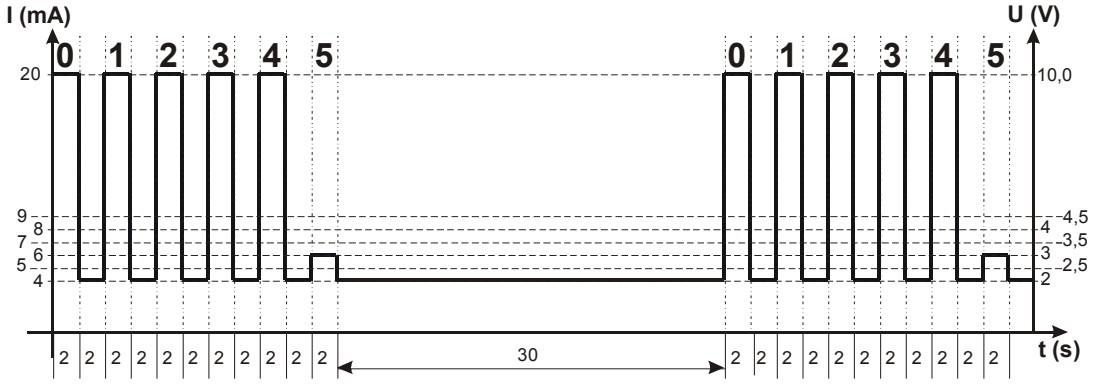
ISO code = (U - 2 V) x (24.28 / 8 V)

HDA.ISO signal 5 (status)

The current or voltage of the output signal (5) is dependent on the status of the TCM as shown in the table below:

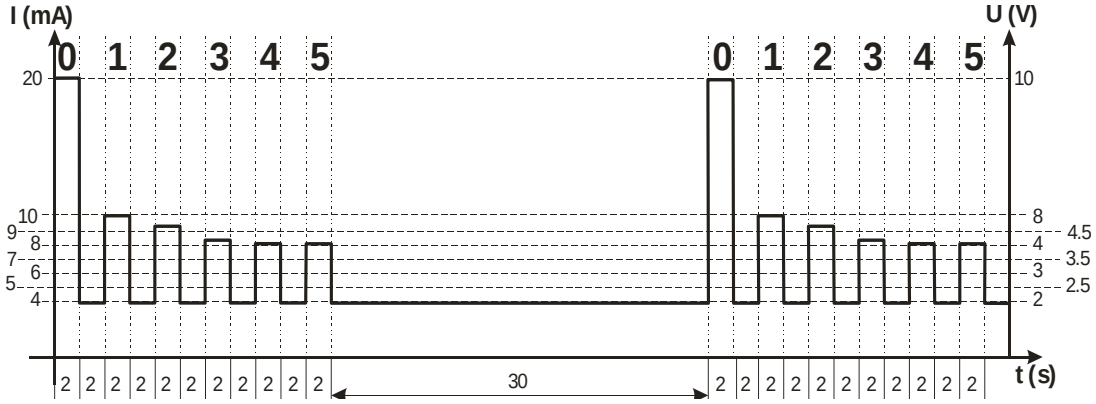
Current I	Status	Voltage U
I = 5.0 mA	The TCM is functioning correctly.	U = 2.5V
I = 6.0 mA	Device error / The TCM is not ready.	U = 3.0V
I = 7.0 mA	The flow rate is too low.	U = 3.5V
I = 8.0 mA	ISO <9.<8.<7	U = 4.0V
I = 9.0 mA	No measured value (The flow rate is not defined.)	U = 4.5V

If the status signal is = 6.0 mA or = 3.0 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	Current I	Voltage U	ISO value
1	9.93 mA	4.97 V	9
2	9.27 mA	4.64 V	8
3	8.61 mA	4.31 V	7
4	7.95 mA	3.98 V	6



NAS 1638 - National Aerospace Standard (Only TCM)

The following NAS values can be read out via the analog output:

- **NAS Maximum**

  Only one value is output.

- **NAS (2 / 5 / 15 / 25)**

  All values are sequentially time-coded before output.

- **NAS 2 / NAS 5 / NAS 15 / NAS 25**

  Only one value is output in each case.

- **NAS+T**

  All values are sequentially time-coded before output.

- **HDA.NAS**

  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal depends on the ISO contamination class 0.0 … 14.0 (resolution 0.1 class) or on an error as described below:

Current I	NAS Class / Error	Voltage U
I < 4.00 mA	Cable break	U < 2.00 V
4.0 mA < I < 4.1 mA	Device error / The TCM is not ready.	2.00 V < U < 2.05 V
4.1 mA < I < 4.3 mA	Not defined	2.05 V < U < 2.15 V
4.3 mA < I < 4.5 mA	Flow error (The flow rate is too low.)	2.15 V < U < 2.25 V
4.5 mA < I < 4.8 mA	Not defined	2.25 V < U < 2.40 V
I = 4.80 mA	NAS 0	U = 2.4V
…	…	…
I = 19.20 mA	NAS 14.0	U = 9.60V
19.2 mA < I < 19.8 mA	Not defined	9.60 V < U < 9.90 V
19.8 mA < I < 20 mA	No measured value	9.90 V < U < 10 V

The current (I) or voltage (U) can be calculated for a given NAS contamination class as follows:

$$I = 4.8\ mA + NAS\ class \times (19.2\ mA - 4.8\ mA) / 14$$

$$U = 2.4\ V + NAS\ class \times (9.6\ V - 2.4\ V) / 14$$

The current I or voltage U can be calculated for a given NAS contamination class as follows:

$$NAS\ class = (I - 4.8\ mA) \times (14/14.4\ mA)$$

$$NAS\ class = (U - 2.4\ V) \times (14/7.2\ V)$$

NAS maximum

The **NAsMAX** value designates the largest of the 4 NAS classes.

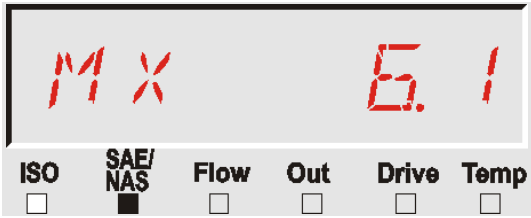
NAS class	2 µm	5 µm	15 µm	25 µm

Particle size	2-5 µm	5-15 µm	15 µm	> 25 µm

The signal is updated after the measuring period has elapsed (the measuring period is set in the PowerUp menu, factory setting = 60 s).

The **NAsMAX** signal is output depending on the maximum NAS class.

Example:

NAS classes	NASMAX (NAS Maximum)
NAS 6.1 / 5.7 / 6.0 / 5.5	

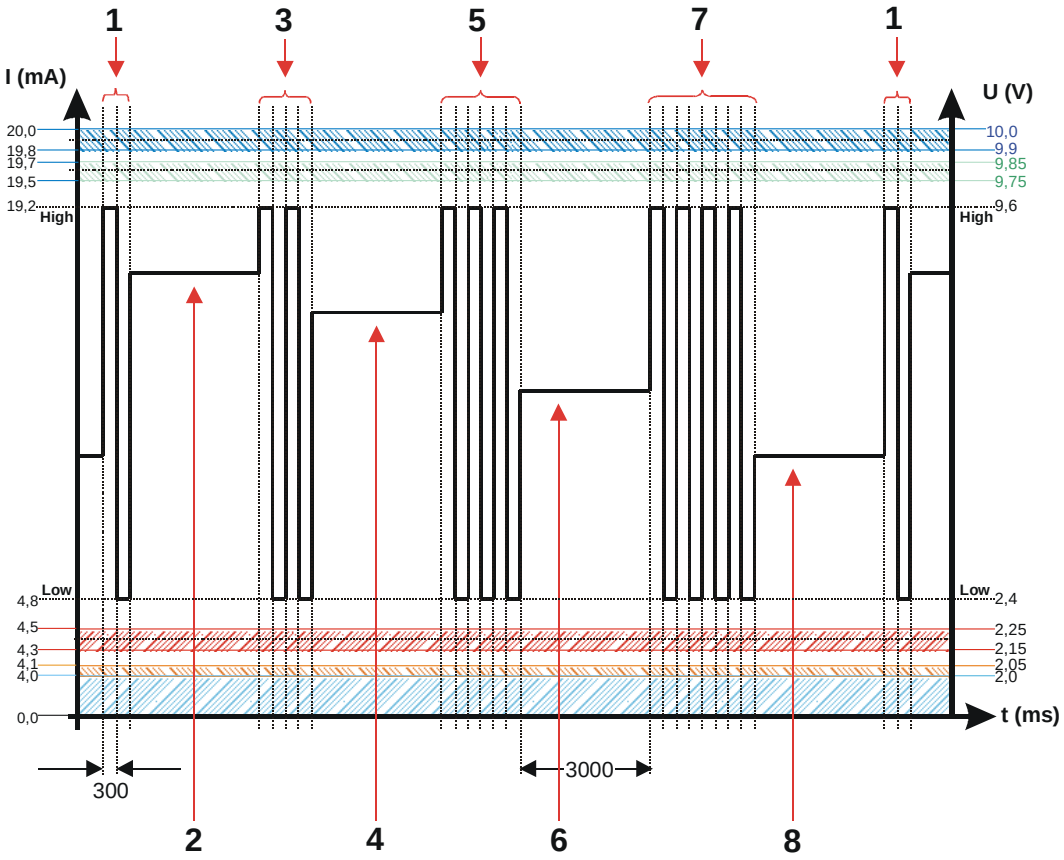
For basic information about cleanliness classes, see page 81 ff.

The NAS classification consists of whole numbers. Better trend recognition is based on a resolution of 0.1 contamination classes as supplied by the TCM 1000.

To convert a decimal value to an integer, the decimal value has to be rounded up.
For example: a readout of NAS 10.7 is, according to NAS, a class NAS 11.

NAS classes (2 / 5 / 15 / 25)

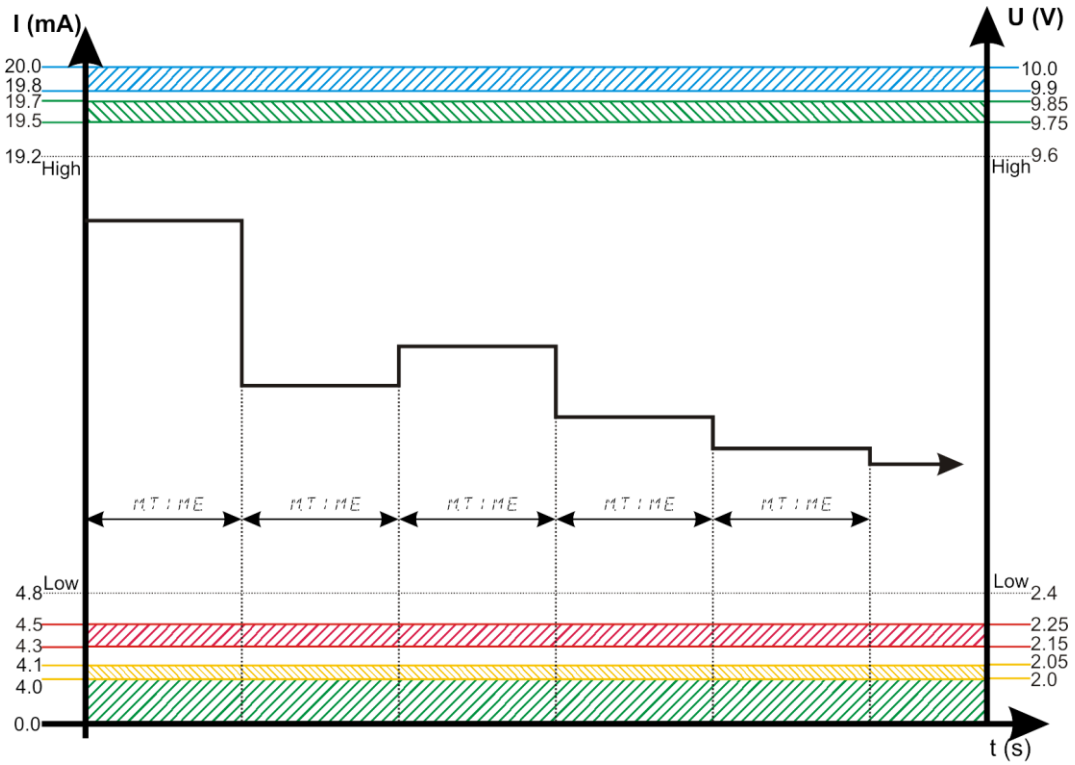
NAS class signals 2 / 5 / 15 / 25 consist of 4 measured values transmitted with the following time-coded time slices:



Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	2 µm	300	High / Low
	2	Measured value	2 µm	3000	Current/Voltage for measured value
	3	Identifier	5 µm	300	High / Low / High / Low
	4	Measured value	5 µm	3000	Current/Voltage for measured value
	5	Identifier	15 µm	300	High / Low / High / Low / High / Low
	6	Measured value	15 µm	3000	Current/Voltage for measured value
	7	Identifier	25 µm	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	25 µm	3000	Current/Voltage for measured value

NAS 2 / NAS 5 / NAS 15 / NAS 25

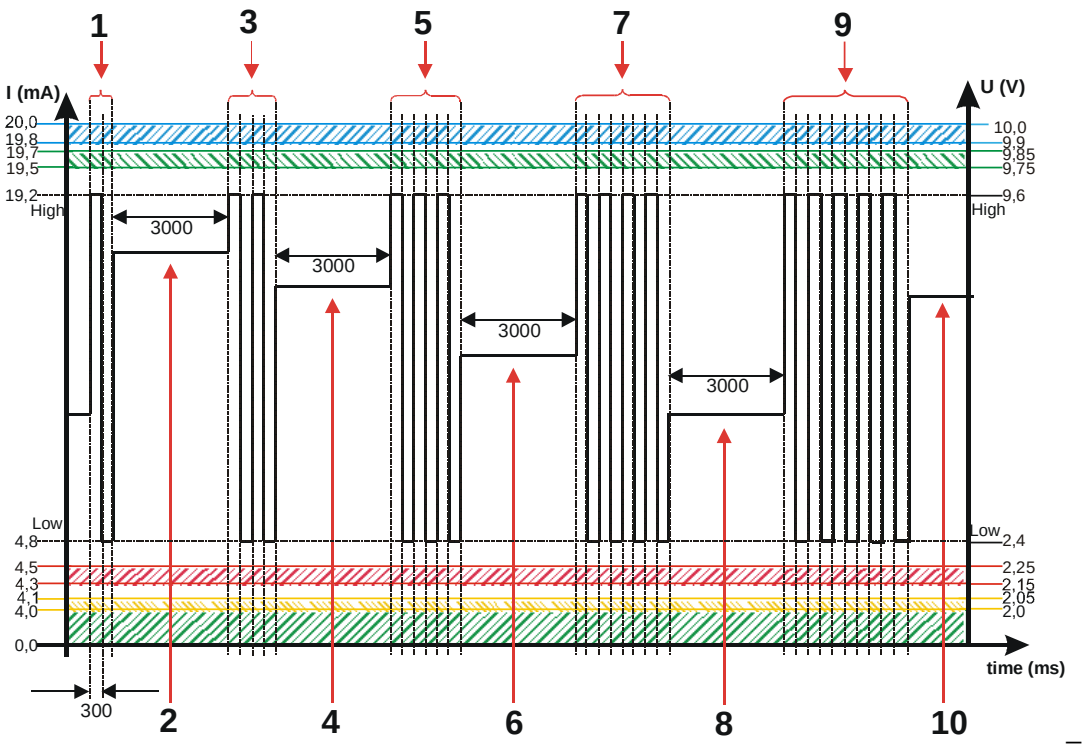
The NAS X signal consists of a measured value (NAS 2 / NAS 5 / NAS 15 / NAS 25) which is permanently transmitted, as described below.



mTIME = Duration of the measurement as set in the PowerUp menu, see page 30.

NAS + T

The NAS+T signal consists of 5 measured values which are transmitted time-coded with the following time slices:

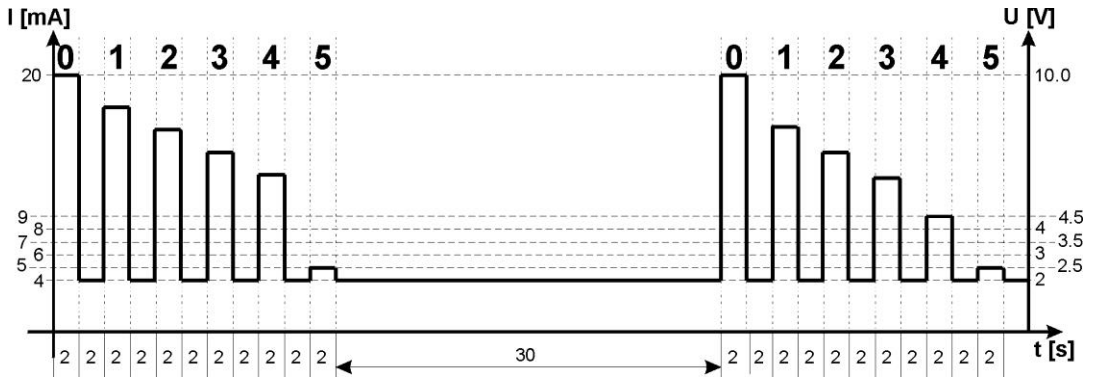


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	2 µm	300	High / Low
	2	Measured value	2 µm	3000	Current for measured value
	3	Identifier	5 µm	300	High / Low / High / Low
	4	Measured value	5 µm	3000	Current for measured value
	5	Identifier	15 µm	300	High / Low / High / Low / High / Low
	6	Measured value	15 µm	3000	Current for measured value
	7	Identifier	25 µm	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	25 µm	3000	Current for measured value
	9	Identifier	T	300	High / Low / High / Low / High / Low / High / Low / High / Low
	10	Measured value	T	3000	Current for measured value

HDA.NAS – Analog Signal NAS to HDA 5500

The HDA.NAS signal consists of 4 measured values (Start / NAS 2 / NAS 5 / NAS 15 / NAS 25 / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	2-5 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	5-15 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	15-25 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	> 25 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current/voltage for signal
	Pause		30	4 mA / 2 V

HDA.NAS Signal 1/2/3/4

The current or voltage range is dependent on the contamination class according to NAS=0.0 … 14.0 (resolution 0.1 class).

Current I	NAS Class / Error	Voltage U
I < 4.00 mA	Cable break	U< 2.00 V
I = 4.00 mA	NAS 0	U = 2.00V
…	…	…
I = 20.00 mA	NAS 14.0	U = 10.00V

The current (I) or voltage (U) can be calculated for a given NAS contamination class as follows:

I = 4 mA + NAS class x (20 mA - 4 mA) / 14

U = 2 V + NAS class x (10 V - 2 V) / 14

The current I or voltage U can be calculated for a given NAS contamination class as follows:

NAS class = (I - 4 mA) x (14/16 mA)

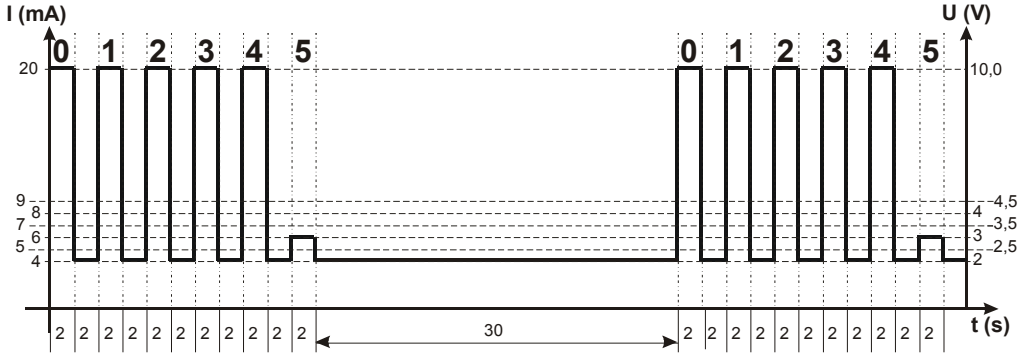
NAS class = (U – 2 V) x (14/8 V)

HDA.NAS signal 5 (status)

The current or voltage of the output signal (5) is dependent on the status of the TCM as shown in the table below:

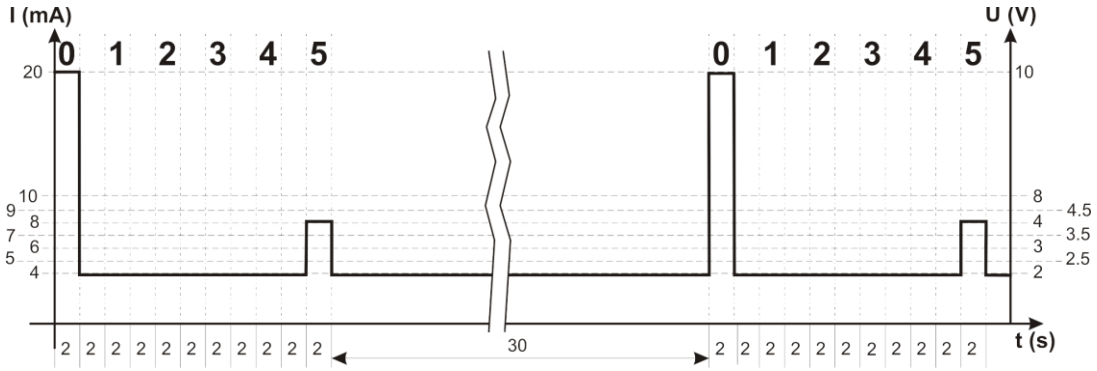
Current I	Status	Voltage U
I = 5.0 mA	The TCM is functioning correctly.	U = 2.5V
I = 6.0 mA	Device error / The TCM is not ready.	U = 3.0V
I = 7.0 mA	The flow rate is too low.	U = 3.5V
I = 8.0 mA	NAS < 0	U = 4.0V
I = 9.0 mA	No measured value (The flow rate is not defined.)	U = 4.5V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	Current I	Voltage U	NAS class
1	4.0 mA	2.0 V	0
2	4.0 mA	2.0 V	0
3	4.0 mA	2.0 V	0
4	4.0 mA	2.0 V	0



Fluid temperature TEMP

The current range 4.8 … 19.2 mA or voltage range 2.4 … 9.6 V is dependent on the fluid temperature of -25°C … 100°C (resolution: 1°C) or -13°F … 212°F (resolution: 1°F) as shown in the table below.

Current I	Temperature / Error	Voltage U
I < 4.00 mA	Cable break	U < 2.00 V
4.0 mA < I < 4.1 mA	Device error / The TCM is not ready.	2.00 V < U < 2.05 V
4.1 mA < I < 4.3 mA	Not defined	2.05 V < U < 2.15 V
4.3 mA < I < 4.5 mA	Flow error (The flow rate is too low.)	2.15 V < U < 2.25 V
4.5 mA < I < 4.8 mA	Not defined	2.25 V < U < 2.40 V
I = 4.8 mA	-25 °C / -13 °F	U = 2.40V
…	…	…
I = 19.20 mA	+100 °C / 212 °F	U = 9.60V
19.2 mA < I < 19.8 mA	Not defined	9.60 V < U < 9.90 V
19.8 mA < I < 20 mA	No measured value	9.90 V < U < 10 V

The current I or voltage U can be calculated for a given temperature as follows:

I = 4.8 mA + (temperature [°C] + 25) x (19.2 mA - 4.8 mA) / 125

I = 4.8 mA + (temperature [°F] +13) x (19.2 mA - 4.8 mA) / 225

U = 2.4 V + (temperature [°C] + 25) x (9.6 V - 2.4 V) / 125

U = 2.4 V + (temperature [°F] + 13) x (9.6 V-2.4 V) / 225

The temperature in °C or °F can be calculated for a given current I or voltage U as follows:

Temperature [°C]= ((I - 4.8 mA) x (125 / 14.4 mA)) - 25

Temperature [°F]= ((I - 4.8 mA) x (225 / 14.4 mA)) - 13

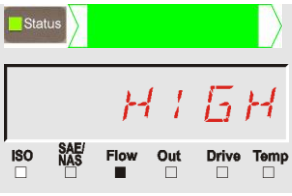
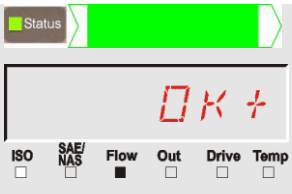
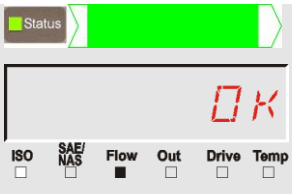
Temperature [°F]= ((U - 2.4 V) x (125 / 7.2 V)) - 25

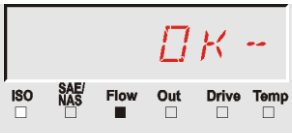
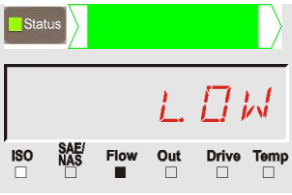
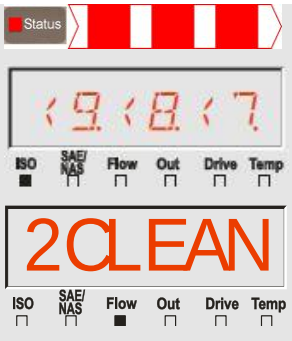
Temperature [°F]= ((U - 2.4 V) x (225 / 7.2 V)) - 13

Status Messages

Status LED / Display

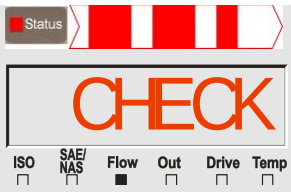
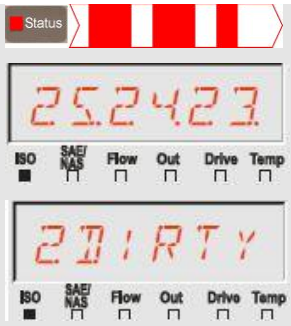
LED	Flash code / display Analogue output Switching output Flow status on the digital output	Status	Remedy	Error no.
Green	 - current value	TCM o.k.	---	-

LED	Flash code / display Analogue output Switching output Flow status on the digital output	Status	Remedy	Error no.
	mA / V* Conductive -			
Green	 current value mA / V* Conductive 55	The flow rate has reached the upper limit.	Reduce the flow rate to prevent the sensor from going into the CHECK error state.	-
Green	 current value mA / V* Conductive 44	The flow rate has reached the upper permissible range.	Check the flow rate in short cycles. The sensor is in the upper permissible flow rate range.	-
Green	 current value mA / V* Conductive 33	The flow rate is in the middle permissible range.	Do nothing. The sensor is in the middle flow rate range.	-
Green		The flow rate has	Check the flow rate in	-

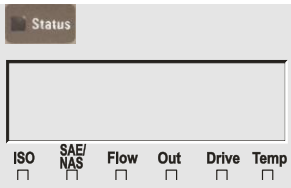
LED	Flash code / display Analogue output Switching output Flow status on the digital output	Status	Remedy	Error no.
	 current value mA / V* Conductive 22	reached the lower permissible range.	short cycles. The sensor is in the lower permissible flow rate range.	
Green	 current value mA / V* Conductive 11	The flow rate has reached the lower limit.	Increase the flow rate to prevent the sensor from going into the CHECK error state.	-
Red	 current value mA / V* Open -1	The sensor is below its measurement range ISO 9/8/7	---	-

error

LED	Flash code / display	Status	To do	Error no.

	Analogue output Switching output Flow status on the digital output			
Red	 19.9 mA / 9.95 V* Open -1	It is not possible to determine the flow rate. The sensor status is undefined.	Check that the flow is between 30 … 500 ml/min. If the fluid cleanliness is below the measurement limit (ISO 9/8/7), it may take several measurement cycles until measured values are displayed.	3
Red	 19.9 mA / 9.95 V* Open -1	The sensor is above its measurement range ISO 25/24/23. It is not possible to determine the flow rate.	Filter the fluid.	3

Exceptions Errors

LED	Flash code / display Analogue output Switching output Flow status on the digital output	TCM Status	To do	Error no.
OFF	 0 mA / 0 V*	TCM no display no function.	Check the supply voltage for the TCM. Contact SCHROEDER .	-

LED	Flash code / display Analogue output Switching output Flow status on the digital output	TCM Status	To do	Error no.
	Open - -			
Red	 - 4.1 mA / 2.05 V* Open -	Firmware error	Reset the unit. (To do this, disconnect the TCM from the voltage supply) or contact SCHROEDER .	-1…-19
Red	 - 4.1 mA / 2.05 V* Open -	Communic. error	Check the wiring.	-20…-39
Red	 - 4.1 mA / 2.05 V* Open -	System error	Reset the unit. (To do this, disconnect the TCM from the voltage supply) or contact SCHROEDER .	-40…-69
Red	 - 4.1 mA / 2.05 V* Open	Error during automatic adjustment	Reset the unit. (To do this, disconnect the TCM from the voltage supply) / check the flow rate or contact SCHROEDER .	-70

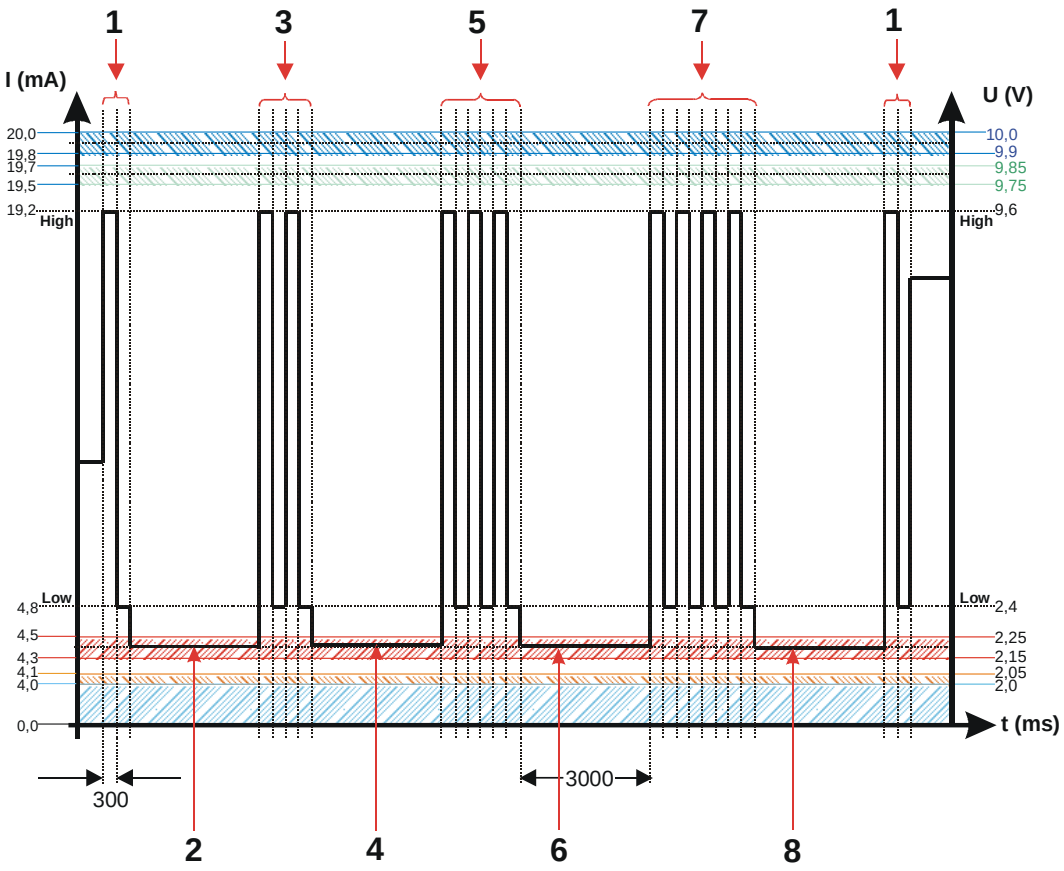
LED	Flash code / display Analogue output Switching output Flow status on the digital output	TCM Status	To do	Error no.
	-			
Red	 - 4.1 mA / 2.05 V* Open -	Error measuring cell LED	Reset the unit. (To do this, disconnect the TCM from the voltage supply) / check the flow rate or contact SCHROEDER .	-100

* Is not valid for HDA 5500 output signal

Analog Output Error Signals

If the TCM enters into an error status all following measured value signals are output in a specific current strength (I) or voltage (U). Please refer to chapter "Error status" for the respective values for the current strength or voltage of the output signal during an error status). The time coding is preserved.

Example: "CHECK" error for the SAE output signal.



Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	SAE A	300	High / Low
	2	Measured value	SAE A	3000	4.4 mA / 2.2 V
	3	Identifier	SAE B	300	High / Low / High / Low
	4	Measured value	SAE B	3000	4.4 mA / 2.2 V
	5	Identifier	SAE C	300	High / Low / High / Low / High / Low
	6	Measured value	SAE C	3000	4.4 mA / 2.2 V
	7	Identifier	SAE D	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	SAE D	3000	4.4 mA / 2.2 V

Analog signal for HDA 5500

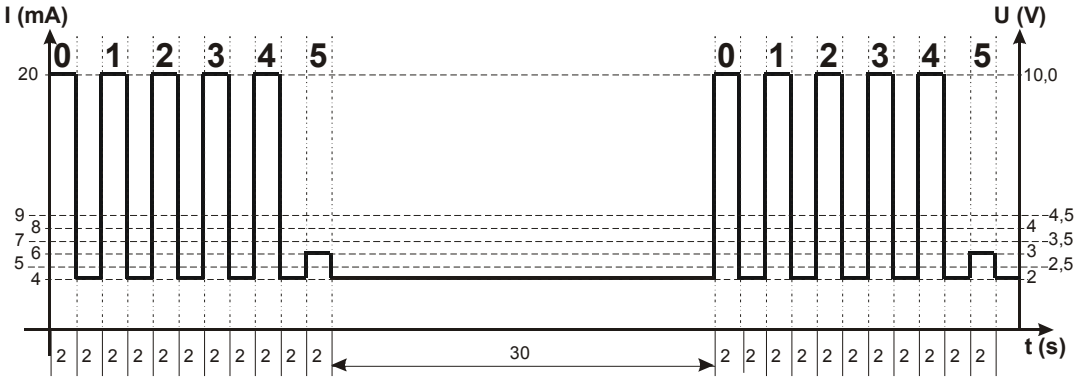
HDA Status Signal 5 Table

The current or voltage of the analog signal (5) is dependent on the status of the TCM as shown in the table below:

Current I	Status	Voltage U
I = 5.0 mA	The TCM is functioning correctly.	U = 2.5V

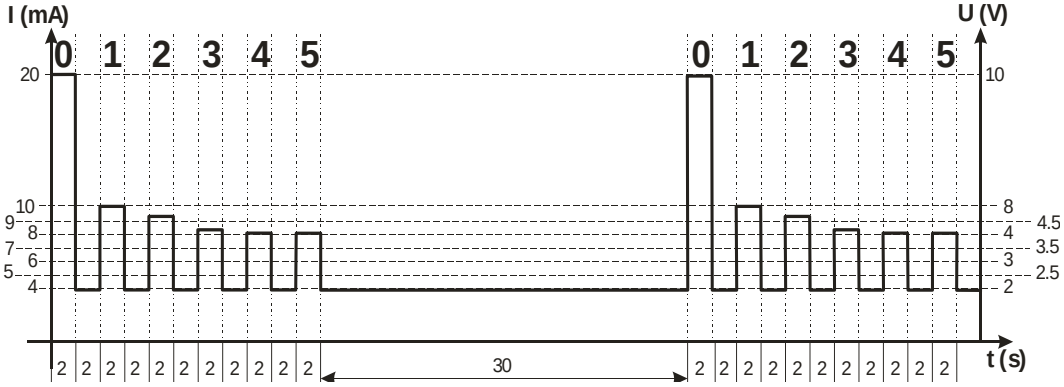
Current I	Status	Voltage U
I = 6.0 mA	Device error / The TCM is not ready.	U = 3.0V
I = 7.0 mA	The flow rate is too low.	U = 3.5V
I = 8.0 mA	ISO <9.<8.<7	U = 4.0V
I = 9.0 mA	No measured value (The flow rate is not defined.)	U = 4.5V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	mA	V
1	10	5.0
2	9.2	4.6
3	8.6	4.3
4	8.0	4.0



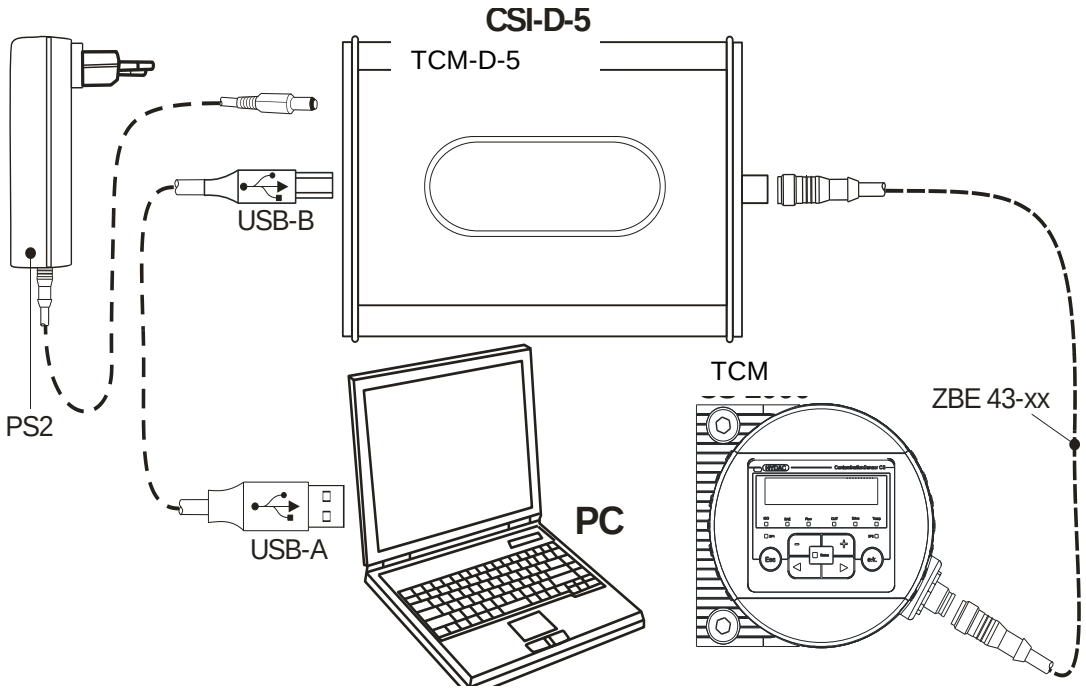
Connecting TCMI-D-5 (Condition Sensor Interface)

The TCMI-D-5 makes it possible to operate the TCM using a PC:

- Setting parameters and limit values.
- Reading out measurement data online.

TCMI-D-5 Connection overview

Connect the TCMI-D-5 to the TCM according to the following connection diagram:



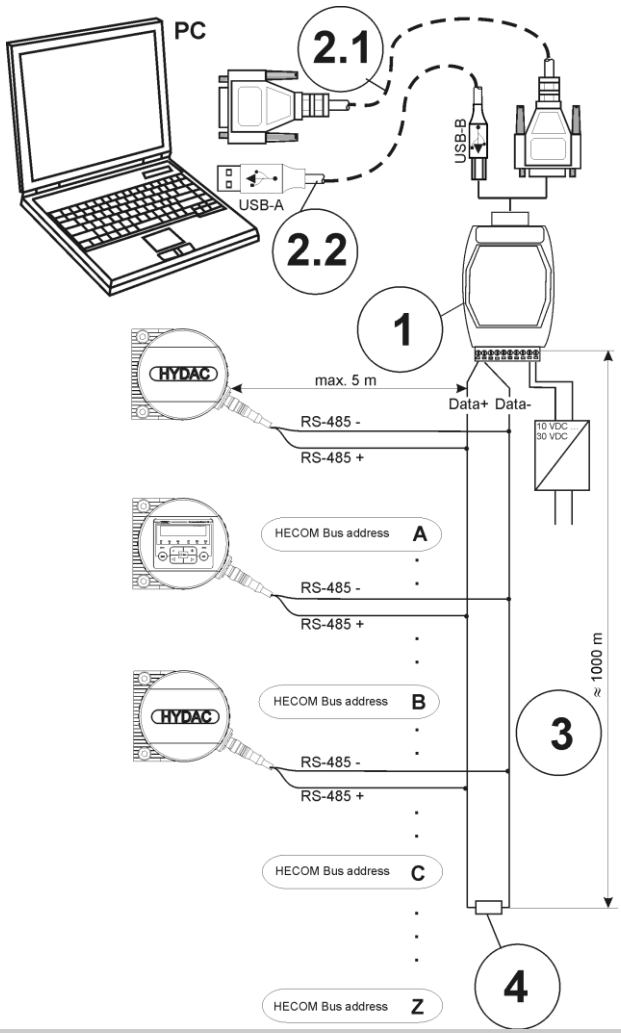
Connecting the TCM to an RS485 bus

The RS485 interface on the TCM is a two-wire interface and operates in half-duplex mode.

The number of TCMs per RS485 bus is limited to 26. Use letters A to Z to address the HECOM bus address.

The length of the bus line and the size of the terminating resistor depend on the quality of cable used.

Connect several TCM's using the RS485 interfaces according to the following illustration:



Item	Description		Part no.:
1	Converter	RS232 <-> RS485	6013281
1	Converter	USB <-> RS485	6042337
2.1	Connection cable	RS232, 9-pole	-
2.2	Connection cable	USB [A] <-> USB [B]	-
3	Recommended cable	twisted pair	-
4	Terminator	~ 120 Ω	-

Communicating with the TCM via the RS485 bus

To communicate with the TCM, start a terminal program (e,g, Hyperterminal) on the PC.

Use the following settings to communicate via the COM interface:

Bits per second	=	9600 Baud
Data bits	=	8
Parity	=	None
Stop bits	=	1

Report	=	None

The TCM can send and receive only HSI commands.

An overview of the HSI commands is provided in our "Getting started" guide for HSI commands, p/no.: 3737763. This "Getting started" guide is available as a PDF on request by sending an email to fltersystems@Schroeder .com.

Taking the TCM out of operation

To decommission, proceed as follows:

1. Disconnect and remove the electric connection to the TCM.
2. Close any shut-off devices in the feed and return lines of the TCM.
2. Depressurize the unit.
3. Remove the hydraulic connection lines to the TCM.
4. Remove the TCM.

Disposing of TCM

Dispose of the packaging material in an environmentally-friendly manner.

After dismantling the device and separating its various materials, dispose of it in an environmentally friendly manner.

Spare Parts and Accessories

Description		Qty	Part no.
CD-ROM with operating and maintenance instructions in different languages		1	3764919
TestMate® Contamination Sensor Interface	TCMI-D-5	1	3249563
O-ring for the flange connection	(4.8x1.78 - 80 Shore FKM)	1	6003048
Socket plug (female) with 5 m line, shielded, 8-pole, M12x1	ZBE 42-05	1	3281239
Extension cable 5 m, Socket plug (female) 8-pole, M12x1 / Socket plug (male) 8-pole, M12x1	ZBE 43-05	1	3281240
Schroeder Digital display unit	HDA5500-0-2-AC-006	1	909925
Schroeder Digital display unit	HDA5500-0-2-DC-006	1	909926

Cleanliness classes - brief overview

Cleanliness class - ISO 4406:1999

In ISO 4406:1999, particle counts are determined cumulatively, i.e. > 4 $\mu m_{(c)}$, >6 $\mu m_{(c)}$ and >14 $\mu m_{(c)}$ (manually by filtering the fluid through an analysis membrane or automatically using particle counters) and allocated to measurement references.

The goal of allocating particle counts to references is to facilitate the assessment of fluid cleanliness ratings.

In 1999 the "old" ISO 4406:1987 was revised and the size ranges of the particle sizes undergoing analysis redefined. The counting method and calibration were also changed.

This is important for the user in his everyday work: even though the measurement references of the particles undergoing analysis have changed, the cleanliness code will change only in individual cases. When drafting the "new" ISO 4406:1999 it was ensured that not all the existing cleanliness provisions for systems had to be changed.

Table - ISO 4406

Assignment of particle counts to cleanliness classes:

	Particle count / 100 ml			Particle count / 100 ml	
Class	More than	Up to (and including)	Class	More than	Up to (and including)
0	0	1	15	16,000	32,000
1	1	2	16	32,000	64,000
2	2	4	17	64,000	130,000
3	4	8	18	130,000	250,000
4	8	16	19	250,000	500,000
5	16	32	20	500,000	1,000,000
6	32	64	21	1,000,000	2,000,000
7	64	130	22	2,000,000	4,000,000
8	130	250	23	4,000,000	8,000,000
9	250	500	24	8,000,000	16,000,000
10	500	1,000	25	16,000,000	32,000,000
11	1,000	2,000	26	32,000,000	64,000,000
12	2,000	4,000	27	64,000,000	130,000,000
13	4,000	8,000	28	130,000,000	250,000,000
14	8,000	16,000			

Note: increasing the measurement reference by 1 causes the particle count to double.

Example: ISO class 18 / 15 / 11 means:

Cleanliness class	Particle count / ml	Size ranges
18	1,300 – 2,500	> 4 $\mu m_{(c)}$
15	160 – 320	> 6 $\mu m_{(c)}$
11	10 – 20	> 14 $\mu m_{(c)}$

Overview of modifications - ISO4406:1987 <-> ISO4406:1999

	"old" ISO 4406:1987	"new" ISO 4406:1999	
Size ranges	> 5 µm > 15 µm		> 4 $\mu m_{(c)}$ > 6 $\mu m_{(c)}$ > 14 $\mu m_{(c)}$
Dimension determined	Longest dimension of a particle		Diameter of the area-equivalent circle ISO 11171:1999
Test dust	ACFTD dust	1-10 µm ultra fine fraction	ISO 12103-1A1
		SAE Fine, AC Fine	ISO 12103-1A2
		SAE 5-80 µm ISO MTD Calibration dust for particle counters	ISO 12103-1A3
		SAE Coarse Coarse fraction	ISO 12103-1A4
Comparable size ranges	Old ACFTD calibration	Comparable ACFTD dusts	New NIST calibration
	----- 5 µm 15 µm	< 1 µm 4.3 µm 15.5 µm	4 $\mu m_{(c)}$ 6 $\mu m_{(c)}$ 14 $\mu m_{(c)}$

Cleanliness class - SAE AS 4059

Like ISO 4406, NAS 4059 describes particle concentrations in liquids. The analysis methods can be applied in the same manner as ISO 4406:1999.

An additional feature in common with ISO 4406:1999 is that cleanliness classes are grouped on the basis of cumulative number of particles (i.e. all particles that are larger than a certain limit value are >4 µm, for example).

As opposed to ISO, SAE AS 4059 uses different limit values among the various particle sizes for contamination classes.

For this reason, the corresponding designation of the particle size being examined always has to be added, e.g.:

AS 4059 class 6B -> 9731 – 19500 particles >6 µm

AS 4059 class 8A/7B/6C -> 3-value ISO code >4µm/>6µm/>14µm

If an SAE class is given acc. to AS 4059 without a letter, then it is always particle size B (> 6 µm).

The following table shows the cleanliness classes in relation to the particle concentration determined:

Table - SAE AS 4059

		Maximum particle count / 100 ml					
Size ISO 4402		> 1 µm	> 5 µm	> 15 µm	> 25 µm	> 50 µm	> 100 µm
Size ISO 11171		> 4 µm(c)	> 6 µm(c)	> 14 µm(c)	> 21 µm(c)	> 38 µm(c)	> 70 µm(c)
Size coding		A	B	C	D	E	F
Classes	000	195	76	14	3	1	0
	00	390	152	27	5	1	0
	0	780	304	54	10	2	0
	1	1,560	609	109	20	4	1
	2	3,120	1,220	217	39	7	1
	3	6,250	2,430	432	76	13	2
	4	12,500	4,860	864	152	26	4
	5	25,000	9,730	1,730	306	53	8
	6	50,000	19,500	3,460	612	106	16
	7	100,000	38,900	6,920	1,220	212	32
	8	200,000	77,900	13,900	2,450	424	64
	9	400,000	156,000	27,700	4,900	848	128
	10	800,000	311,000	55,400	9,800	1,700	256
	11	1,600,000	623,000	111,000	19,600	3,390	512
	12	3,200,000	1,250,000	222,000	39,200	6,780	1,020

Definition acc. to SAE

Particle count (absolute) larger than a defined particle size

Example: Cleanliness class according to AS 4059: 6

The maximum permissible particle count in the individual size ranges is bold-faced in the table on page 83.

Cleanliness class acc. to AS 4059= 6 B

Size B particles may not exceed the maximum number indicated for code 6: 6 B = max. 19,500 particles > 5 µm in size

Specifying a cleanliness code for each particle size

Example: Cleanliness class according to AS 4059=7 B / 6 C / 5 D

Cleanliness class	Max. particles / 100 ml
Size B (> 5 µm / > 6 µm(c))	38,900

Size C (>15 µm / >14 $\mu m_{(c)}$)	3460
Size D (>25 µm / > 21 $\mu m_{(c)}$)	306

Specifying highest measured cleanliness class

Example: Cleanliness class according to AS 4059= 6 B – F

The 6 B – F specification requires a particle count in size ranges B – F. The respective particle concentration of cleanliness class 6 may not be exceeded in any of these ranges.

Cleanliness Class - NAS 1638

Like ISO 4406, NAS 1638 describes particle concentrations in liquids. The analysis methods can be applied in the same manner as ISO 4406:1987.

In contrast to ISO 4406, certain particle ranges are counted in NAS 1638 and attributed to measurement references.

The following table shows the cleanliness classes in relation to the particle concentration determined:

		Maximum particle count / 100 ml					
		2..5 µm	5..15 µm	15..25 µm	25..50 µm	50..100 µm	> 100 µm
Cleanliness class	00	625	125	22	4	1	0
	0	1,250	250	44	8	2	0
	1	2,500	500	88	16	3	1
	2	5,000	1,000	178	32	6	1
	3	10,000	2,000	356	64	11	2
	4	20,000	4,000	712	128	22	4
	5	40,000	8,000	1,425	253	45	8
	6	80,000	16,000	2,850	506	90	16
	7	160,000	32,000	5,700	1,012	180	32
	8	320,000	64,000	11,400	2,025	360	64
	9	640,000	128,000	22,800	4,050	720	128
	10	1,280,000	256,000	45,600	8,100	1,440	256
	11	2,560,000	512,000	91,200	16,200	2,880	512
	12	5,120,000	1,024,000	182,400	32,400	5,760	1,024
	13	10,240,000	2,048,000	364,800	64,800	11,520	2,048
	14	20,480,000	4,096,000	729,000	129,600	23,040	4,096

Increasing the class by 1 causes the particle count to double on average.

Checking/resetting default settings

PowerUp menu

PowerUp menu	Value	
MODE	**M1**	
M.TIME	**60**	
pPRTCT	**0**	
ADRESS	**HECOM**	**A**
CALIB	**ISoNAS**	(TCM 13xx, only)

Mode	Value				
MODE	**M2**	**SP1**	**MEAS.CH**	**SAeMAX**	
MODE	**M2**	**SP1**	**SW.FNCT**	**BEYOND**	
MODE	**M2**	**SP1**	**LIMITS**	**LOWER**	**17.15.12**
MODE	**M2**	**SP1**	**LIMITS**	**UPPER**	**21.19.16**
MODE	**M3**	**MEAsCH**	**ISO**		
MODE	**M3**	**TARGET**	**17.15.12**		
MODE	**M4**	**MEAsCH**	**ISO**		
MODE	**M4**	**TARGET**	**17.15.12**		
MODE	**M4**	**RESTART**	**21.19.16**		
MODE	**M4**	**CYCLE**	**60**		

Measuring menu

Measuring menu	Value
DSPLY	ISO
SWtOUT	M1
ANaOUT	HDaISO

Specifications

General data	
Mounting position	Any (recommended: vertical position)
Self-diagnosis	continuously with error indication via status LED and display

Display (only TCM 1x2x)	LED, 6 digits, in 17 segment format
Measured variables	TCM 12xx ISO / SAE TCM 13xx ISO / SAE / NAS
Service variables	Flow Status Out mA or VDC depending on model Drive % Temp °C and °F
Ambient temperature range	-30 … 80 °C / -22 … 176 °F
Storage temperature range	-40 … 80 °C / -40 … 176 °F
Relative humidity	max. 95%, non-condensing
Material of sealings	TCM 1xx0 FKM TCM 1xx1 EPDM
Protection class	III (safety extra-low voltage)
IP class	IP 67 (only with screw-lock connectors)
Weight	~ 1.3 kg
Hydraulic data	
Operating Pressure	maximum 350 bar / 5075 psi
Hydraulic connection - Pipe or hose connection - Flange connection	 Thread G ¼ according to ISO 228 DN 4
Permitted measurement flow rate	30 … 500 ml/min
Permissible viscosity range	1 … 1000 mm²/s
Fluid temperature range	0 …80 °C / 32 …185 °F
Electrical data	
Connection plug	M12x1, 8 pole, specified in DIN VDE 0627
Supply Voltage	9 … 36 V DC, residual ripple < 10%, (protected against polarity reversal)
Power consumption	3 W max.
Analogue output	2-conductor technology 4 … 20 mA active output (max. burden 330Ω) or 2 … 10 V active output (minimum load resistance 820 Ω)
Switching output	passive, n-switching Power MOSFET: maximum switching current 2 A, maximum switching voltage 30 V DC, dead open
RS485 Interface	2 wire, half duplex
SSI (**SCHROEDER S**ensor **I**nterface)	1 wire, half duplex

Recalibration

We recommend recalibrating the sensor every 2 … 3 years unless otherwise specified.

Customer Service

For calibration and repair, send the sensor to the following address:

580 West Park Road

Leetsdale, PA 15056

Glossary

Single measurement	A single measurement means the analysis of the contamination in a sample, which flows through the sensor during the configured measurement period. The result of a single measurement is the *measured value*.
Meas. point	This is the name for the point in the hydraulic system where a measurement is carried out.
Test volume	Sample quantity which is analyzed for determining a *measured value*.
Measured value	The contamination codes determined by a single measurement, shown as a three-digit ISO code or NAS codes or SAE codes of the individual particle size channels.
Measurement duration	Once the measurement duration has elapsed, the measured value is updated which is shown on the display and presented at the interface. The measurement duration is configurable using the M.TIME parameter.
Measurement	Once a TCM device has been connected to the electrical power and its boot process has completed, a *single measurement* will start, after which the next *single measurement* will immediately follow, and so on, until the TCM device is disconnected from the power (MODE M1, M2, M4) or until the programmed target purity (MODE M3) has been reached. This series of *single measurements* is referred to as a *measurement* for convenience reasons.